FORWARD SURGERY

OF THE

SEVERELY WOUNDED

VOLUME I

A History of the Activities

of the

2nd Auxiliary Surgical Group

1942 - 1945

HEADQUARTERS
2ND AUXILIARY SURGICAL GROUP
APO 512, US Army

27 August 1945

Letter of Transmission

SUBJECT: Forward Surgery of the Severely Wounded (A History of the Activities of the 2nd Auxiliary Surgical Group)

TO: The Surgeon General
Army Service Forces
Washington, D.C.

Submitted herewith is the History of the Activities of the 2nd Auxiliary Surgical Group entitled, "Forward Surgery of the Severely Wounded".

James H. Forsee
JAMES H. FORSEE
Colonel, MC
Commanding

1st Ind.
HEADQUARTERS MTOUSA, OFFICE OF THE SURGEON, APO 512, 18 October 1945.

TO: The Surgeon General, U.S. Army, Washington 25, D.C.

E.S.

2 Incls.
Incl 1 - Vol I
Incl 2 - Vol II

I N

M E M O R I A M

Killed In Action:

Major John E. Adams, MC, AUS

2nd Lt LaVerne Farquhar, ANC

Technician Fifth Grade Theron McCombs

Died In The Service:

Technician Fifth Grade Ewaldt F. Hasenwinkel

P R E F A C E

In the history of modern warfare it is doubtful if a group of American surgeons have ever had such a vast experience in the surgical care of severely wounded casualties as have members of the 2nd Auxiliary Surgical Group. This experience was gained in two active Theaters of Operations, the North African, later to become the Mediterranean Theater, and the European Theater of Operations. The period covered is from 1 May 1942 to 27 August 1945. The campaigns in which this organization has participated are: the Tunisian, Sicilian, Naples-Foggia, Rome-Arno, North Apennines, Po Valley, Southern France, Rhineland and Central Europe. Advanced elements of the unit were engaged in the French Morocco-Algeria Campaign. It has participated in the initial landings of five major amphibious operations in NATOUSA. Such an extensive experience cannot be accurately depicted solely by the tabulation of statistical data referable to the casualties from these campaigns who were treated by members of this Group. A comprehensive appraisal of the nature and severity of the injuries as well as the principles and procedures that have been evolved in their management has been made by members of this Group and is presented in this report. These casualties were those which, in the vast majority of instances, required immediate care and could not be safely transported beyond the rear boundary of the division without surgery. They have been designated as nontransportables. Churchill's description of these casualties places them in two categories: First, those requiring the correction of profound physiological disturbances which immediately endanger life; secondly, those requiring the arrest or prevention of the complications of infection that, if allowed to develop or progress may endanger life or lead to grave disability. The initial surgical management of battle casualties suffering from the above types of wounds constituted the principal function of this organization.

An indication of the surgical experience of this Group in the forward surgery of the severely wounded is evidenced by the following data: 2629 casualties suffering from intra-abdominal wounds, 903 from thoraco-abdominal, 1364 from intrathoracic, 915 from traumatic amputations, 2416 from severe compound fractures of long bones, and 574 from serious head wounds were among the casualties who received their initial surgery by members of the Group*. These data do not include approximately 2000 patients suffering from intrathoracic injuries and approximately 1000 patients with maxillofacial injuries who received their reparative surgery from members of this Group at specialty centers in base hospitals. In all, approximately 22,000 casualties have received operative surgery by members of this Group. On each of the patients, a carefully recorded case record has been made at the time of operation and retained at the

* The great majority of these casualties were treated in first priority surgical hospitals (a platoon of a Field Hospital) located adjacent to division clearing stations.

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Group Headquarters. It is believed that no similar number of case records of battle casualties suffering from the types of wounds described above is available in the annals of American surgery. Foresight and constant diligence have been responsible for recording this large amount of data.

Throughout the entire existence of this organization, the teams have functioned in other medical installations, and any success they have achieved has been due in a very appreciable degree to the splendid cooperation rendered by these installations. Surgical and shock teams of this unit have been employed in 53 different American hospitals and medical installations, 18 different British hospitals and medical installations, and in two Italian hospitals while overseas. During the period in which the unit was in the United States, it was stationed at Lawson General Hospital. To the staffs of each of these installations as well as the staffs of the medical sections of base sections, Corps, Armies and Theaters in which the Group has functioned, deep appreciation is acknowledged. Naturally, many individuals have greatly aided in making it possible for this unit to carry out its mission properly. Their number is so large that adequate credit cannot be recorded here. The history of this organization would not be complete without recording grateful appreciation to the following individuals:

Colonel Edward D. Churchill, MC, Consulting Surgeon, NATOUSA and MTOUSA. Colonel Churchill's great vision, understanding and surgical knowledge have been the inspiration guiding the surgical pursuits of this organization in its overseas experience.

Colonel Frank B. Berry, MC, Surgical Consultant, Seventh Army (formerly Chief, Surgical Service, 9th Evacuation Hospital). Colonel Berry has been a close friend of this organization since the early days of the Tunisian Campaign. His direction of the surgical efforts in the Seventh Army was a beacon light in the experience of this Group.

Major General Morrison C. Stayer, Theater Surgeon, NATOUSA and MTOUSA, was the force which carried through many measures that enabled this organization to accomplish its mission.

Brigadier General Joseph I. Martin, Surgeon, Fifth Army, was tireless in his efforts to make available all facilities needed to permit this Group to bring to the severely wounded soldier its surgical talents. To the following members of his staff, grateful acknowledgement is accorded: Colonel Clement F. St John, MC, Operations Officer; Colonel Howard E. Snyder, MC, Surgical Consultant; Colonel Charles O. Bruce, MC, Executive Officer, Lt Col Marcel H. Mial, SnC, Supply Officer; and Major Helen E. Wharton, ANC, Director of Nurses.

Colonel Myron P. Rudolph, MC, Surgeon, Seventh Army, was the wise counsellor and friend of this unit in the days in North Africa and for that portion of the Group which functioned with the Seventh Army in France

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and Germany. To the following members of his staff, grateful acknowledgement is accorded: Colonel Albert H. Robinson, MC, Executive Officer, Colonel Joseph Rich, MC, Operations Officer: Lt Col A. J. Guenther, MAC, Supply Officer; and Major Edith F. Frew, ANC, Director of Nurses.

Colonel Richard T. Arnest, MC, Surgeon, II Corps, during the Tunisian and Sicilian Campaigns. Colonel Arnest lent immeasurable assistance to the surgical teams of this Group which participated in these campaigns. The experience gained in these early campaigns did much in formulating the policy for the future employment of this Group.

Brigadier General Fred W. Rankin, Chief Consultant in Surgery, Office of the Surgeon General, US Army, Washington, D.C. General Rankin early recognized the importance of the proper selection of personnel for this Group. His accurate and detailed knowledge of the personnel possessing the surgical training and ability required for the surgeons of this Group resulted in the meticulous selection of its original personnel. If the mission of the Group has been accomplished in a measure commensurate with what he envisioned in the selection of its professional staff, great pride may be rightly felt by the members of the Group.

General Mark W. Clark, Commanding General, 15th Army Group. During the period 9 September 1943 to 15 December 1944, this organization was privileged to serve under the direction of General Clark, then Commanding General, Fifth Army.

Lieutenant General Alexander M. Patch, Commanding General, Seventh Army. The smooth functioning of this organization with the Seventh Army in France and Germany was greatly enhanced by the earnest desire and interest of General Patch to provide the best possible surgical care to the wounded soldiers.

Lieutenant General Lucian K. Truscott, Jr., Commanding General, Fifth Army. Throughout the field experience of this organization, General Truscott has been the commander most closely allied with its efforts. As Commanding General, 3rd Division in Sicily and the early battles on the Italian mainland, later as Commanding General, VI Corps, throughout most of the battle at Anzio, the campaigns of Southern France and part of the Rhineland, and finally as Commanding General, Fifth Army, General Truscott has been the sincere friend of this organization.

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I. GENERAL CONSIDERATIONS IN THE SURGICAL MANAGEMENT OF THE SEVERELY WOUNDED

THE EMPLOYMENT AND FUNCTION OF TEAMS OF THE 2ND AUXILIARY SURGICAL GROUP

No nation had attained the high standard of surgical training available to as large a number of young surgeons as the United States at the time of its entry into World War II. However, economy in their employment and the proper utilization of their surgical talents were required if soldiers wounded in battle were to receive the best surgical care that this nation was capable of extending. For a brief period near the close of World War I, certain qualified young surgeons were selected to be in charge of surgical teams which functioned in the most forward hospitals. These teams successfully operated upon many casualties who could not be safely transported further to the rear without surgery. This experience indicated the feasibility of employing surgical teams in the forward hospitals in order to attain the most efficient use of such personnel. Also surgical specialty teams were designated to function in other hospitals, including maxillofacial and neurosurgical teams. Upon this basis, there was planned within the United States Army an organization composed of highly qualified surgeons, nurses and enlisted men constituted into surgical teams. Their function was, primarily, to augment the staffs of forward hospitals in the surgical management of battle casualties. This organization was designated as an Auxiliary Surgical Group. It is composed of general and specialty (thoracic, neurosurgical, orthopedic and maxillofacial plastic) surgical teams and shock teams. The activities of the Group are directed by its Group Headquarters. This scheme of organization has been successful in effecting a readily available source of well qualified professional personnel for immediate employment in forward hospitals. It has achieved a uniformity of control of this portion of surgical personnel which has produced a high level of competence as well as economy in the deployment of specialized skill and talent. The teams are equipped with instruments and an anesthesia apparatus. From their Group Headquarters they are sent on short notice to any hospital needing their assistance.

The developments in World War II led to a broadening of the concepts relative to the surgical care of the most seriously wounded battle casualties. This permitted the focusing of attention on such casualties so that they might receive expert surgery at the farthest point forward where proper facilities for their care could be made available. It was at this level in the chain of evacuation and in the surgical care of the desperately wounded casualties that the employment and functions of the surgical and shock teams of this Group were concentrated. The general surgical and thoracic surgical and shock teams were of greatest usefulness in the surgical care of first priority casualties, i.e. nontransportables. The developments in NATOUSA led to the establishment of a first priority surgical hospital (a platoon of a Field Hospital) located adjacent to the division clearing station. This priority hospital was devoted exclusively to the care of the nontransportable casualties. The professional care of patients in these hospitals was the responsibility of the surgical teams of this Group functioning in the Fifth and Seventh Armies. The method of employment of the priority surgical hospitals and the manner

in which the functions of the surgical and shock teams of this Group were coordinated in these installations to effect the high standard of surgery maintained in the care of the most seriously wounded casualties are detailed elsewhere in this report. A brief presentation of this information even at the sake of repetition will permit a better understanding of the conditions under which the surgery recorded in this report was accomplished.

A first priority surgical hospital is a small mobile installation which was usually established in tentage; buildings were used when available. At the division clearing station triage based on the urgency of the wound and the condition of the casualty was accomplished. Nontransportable patients were transferred immediately to the priority hospital, often by hand litter. "Expert surgical management that embraces resuscitation, operation and prolonged postoperative care, becomes immediately available and the desperately wounded receive expert care as far forward as it can be provided".[1] The surgical and shock teams functioned in these hospitals on a temporary duty status and had complete responsibility for the professional care of the patients treated. Four to six surgical teams, ideally one thoracic surgical and the others general surgical, and two shock teams were required in a busy priority hospital. To support adequately one actively engaged infantry division, two platoons were required. The assigned staff of the hospital was small. One medical officer of the regular staff was usually available to assist in the administration of shock therapy; other male officers were engaged in the operation of the hospital. The nursing staff of the hospital provided the ward nursing service while the surgical nurse members of the attached teams functioned with their respective teams in operative surgery. The hospital and attached surgical teams were able to move on short notice and on arrival at their new location to begin functioning in two hours. In practice these hospitals leapfrogged one another, and the hospital or part of it was left behind to become the "holding unit". Sufficient hospital personnel remained with the "holding unit" to care for patients until they could be safely evacuated. One surgical team remained with the "holding unit". The facilities afforded in a first priority hospital must be limited in comparison to a fixed hospital (Station or General Hospital). However, all essential in equipment were available and highly qualified surgeons were charged with the care of the severely wounded casualties. This combination achieved a degree of success which adds a new phase to American surgery in modern warfare.

"A well run first priority surgical hospital exerts a remarkably favorable effect on the morale of combat troops and their officers".[1] The front line soldier knew that if he should be seriously wounded he would receive immediate and expert priority surgical care and that such care would greatly enhance his chances of recovery.

The casualties admitted to the division clearing station suffering from less urgent wounds and in condition to be transported were transferred to Evacuation Hospitals located usually five to fifteen miles

Figure 1

Figure 1. Panorama of Field Hospital (left foreground) and Division Clearing Station (right forground).

behind the division clearing station. These hospitals handled the great bulk of wounded in the forward area as the group diverted to the first priority surgical hospital constituted approximately 8% of the total number.[1] These installations had trained and experienced professional staffs. During periods of heavy fighting their staffs were augmented by surgical teams from the Auxiliary Surgical Group. These teams included particularly the specialty teams, i.e. thoracic, neurosurgical, and orthopedic surgical. The general surgical teams were often required in Evacuation Hospitals. When teams functioned in these hospitals they worked under the direction of the Chief of the Surgical Service.

It is desirable to emphasize at this point that a new era in the surgical management of desperately wounded battle casualties has been achieved. The remarkable results obtained in the surgical care of these casualties will become evident from a study of the data detailed in the subsequent sections of this report. Certain data available from the records of the American Expeditionary Force of World War I are significant in demonstrating the marked advances noted in the experience of this Auxiliary Surgical Group. In the American Expeditionary Force, World War I, 11 per 1000 patients admitted to hospitals suffered from abdominal wounds.[2] The mortality rate among these patients was 66.8%.[2] During the 20 months fighting experience of the Fifth Army, 35 battle casualties per 1000 admitted to hospitals suffered from intra-abdominal wounds. The mortality rate of 3154 patients with intra-abdominal wounds treated during 1944 and 1945 by members of this Group was 24%. These data become even more significant when it is appreciated that the increased rate of admission of such casualties is in the group of the most severely wounded. If only the less severe abdominal wounds are considered, which probably would be more nearly comparable to the World War I series, the mortality rate closely approximates 13% (page 110). A similar marked improvement in the management of thoracic wounds has been achieved. In World War I, the frequency of admissions to hospitals was 10.5 per 1000 with a mortality rate of 47.68%. In the Fifth Army, the frequency was 48 per 1000, and the mortality rate among 1364 patients suffering from intrapleural injuries, treated by members of this Group, was 9.89%. Figures are not available from World War I relative to thoraco-abdominal wounds, but a mortality rate of 27.35 among 903 casualties suffering from such injuries treated by members of this Group is a worthy achievement.

The careful recording of data relative to the surgical management rendered casualties by members of this Group has enabled a detailed study of the problems of forward surgery. These records have been made by the surgeons of the Group while working under the extremely hazardous conditions of enemy observation, shelling and bombing, often during inclement weather while living in tents, and during periods of rapid movements and prolonged and sustained periods of intense surgical activity. The records have been meticulously preserved and have become the source material

for the factual data recorded in this report. It is urgently hoped that they will be maintained for future reference and study cordinated with follow-up data.

The professional service section of this report represents the combined surgical experience of the Group. The compilation of the data contained in the report has been accomplished through the efforts of the great majority of the medical officers of the organization and has been in progress at varying periods during the past two years. In fact, plans were formulated for recording the combined surgical experience of the Group even before it participated in an active Theater of Operations. The final effort to compile these data was accomplished after the end of the war in Europe. At that time certain members of the Group were not available to assist in this work as some were employed with functioning teams and some had returned to the United States. All other medical officers of the Group participated in the final compilation of this report. Major Luther H. Wolff, MC, was in charge of the final preparation of the professional service section of this report. For the past eight months the major portion of his time has been devoted to this work. His able direction of this large undertaking is reflected in the excellence of the professional service section. In July 1945, a board of officers was designated as an editorial board for the preparation of the professional service section of this report. Captain Maurice J. Walsh, MC, ably assisted the board in preparation of the report. Captain Paul A. Kennedy, MC, assisted by Pfc Walter Meigs, Jr., was responsible for the preparation of the charts and graphs contained in this report.

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1. Churchill, Edward D.: The Surgical Management of the Wounded in the Mediterranean Theater at the Time of the Fall of Rome. Annals of Surgery, 120:268. September 1944.

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3. Data obtained from the Office of the Surgeon, Fifth Army, (US).

PREOPERATIVE DIAGNOSIS AND TRIAGE

PREOPERATIVE DIAGNOSIS AND TRIAGE

Preoperative diagnosis in War Surgery is simply the study of injury and its effects upon the wounded man. If the injury is severe, grave physiological disturbances often result which threaten life and successful resuscitation cannot be accomplished without an evaluation of the responsible factors. If fulminating infection is beginning but escapes detection, life may be lost as the result of incomplete diagnosis and the consequent delay in operative care. Likewise, intelligent surgical care is impossible without an accurate knowledge of the extent and nature of the injury as well as the structures which are involved.

In evaluating the condition of the severely wounded it is first necessary to attend to those disturbances which constitute an immediate threat to life or jeopardize the ability of the patient to withstand operation. Of greatest importance in this respect is traumatic or wound shock; its evaluation and management become the immediate problem which takes precedence over other diagnostic measures.

THE DIAGNOSIS OF SHOCK: THE EVALUATION OF THE DEGREE OF SHOCK

A reduction in circulating blood volume and concomitant decrease in peripheral blood flow are believed to be the most early disturbances in the syndrome of shock (1). It is important to realize that the recognition of shock depends upon the clinical manifestations of these circulatory disturbances. The determination that the shock does not exist is ordinarily not difficult. It appears that individuals vary considerably in their response to trauma and that the degree of shock is not always strictly parallel to the blood volume loss, particularly when this loss has not been severe (2). This fact must always be remembered in any discussion relative to the degree of shock.

It has become customary to speak of shock in which the blood pressure is normal as "incipient shock". This is a useful concept for two reasons: first, it indicates that the fundamental disturbance of shock may exist without a fall in the blood pressure; secondly, it implies the progressive nature of the peripheral circulatory failure which follows trauma. The recognition of incipient shock depends largely upon evidences of decreased peripheral blood flow (pallor and coldness of the skin and extremities; collapse or constriction of the superficial veins; and tachycardia with a pulse of poor volume). The degree of these changes may vary considerably from patient to patient but is of extreme importance in indicating that a reduction of the circulating blood volume has occurred, regardless of the level of the blood pressure.

Preoperative Diagnosis and Triage. (The Diagnosis of Shock: The Evaluation of the Degree of Shock , contd).

Blalock (3) has repeatedly called attention to the fact that the blood pressure is a poor index of the degree of shock and that a considerable reduction in blood volume and blood flow often occurs prior to a fall in blood pressure. Studies in this Theater (2) have shown that a blood loss of 20-30% of the expected blood volume may occur in battle casualties without an appreciable reduction in the blood pressure. Richards (1) cites evidence for a strong selective vasoconstrictor activity in shock which curtails markedly the blood flows to organs not immediately necessary for survival. He also states, "Spontaneous and abrupt failure of this selective vasoconstriction may precipitate fatal collapse". These findings support the conclusion that a fall in blood pressure indicates a reduction in the circulating blood volume for which vasoconstriction cannot fully compensate or that a failure of the vasoconstrictor mechanism has occurred. In previously healthy soldiers intense vasoconstriction usually persists until death occurs and little clinical evidence exists that vasoconstriction fails in the sense that arteriolar dilation supervenes. However, the marble-like mottled cyanosis which is occasionally seen in moribund patients may constitute evidence for arteriolar dilatation in such cases.

In the recognition of the more severe degrees of shock, a falling blood pressure will always remain as one of the cardinal signs of progressing circulatory failure. Experience with the severely wounded indicates that this fall in blood pressure is almost always associated with increasing vasoconstriction and progressive reduction in the peripheral blood flow. Hence, the clinical correlation of the state of the peripheral circulation with the level of the blood pressure constitutes an important means of evaluating the severity of shock. The skin may be excessively cold and pale; the pulse may be barely perceptible or tend to disappear with inspiration and the rate very rapid; often there is evidence of marked constriction of the superficial veins. As the manifestations of stagnant anoxia become apparent the skin exhibits the ashen-grey cyanosis so characteristic of profound shock, and cerebral anoxia often results in restlessness, apathy, or stupor. True coma is relatively rare except in the moribund patient. In the most severe examples of shock the blood pressure in the brachial artery may be unmeasurable, even inpalpable - and death is immediately threatened. Sweating may be observed in severe shock but it also occurs when shock is minimal or absent and has proved to be of little aid in evaluating the degree of shock.

In the use of the blood pressure level as an indication of the degree of shock it is important to determine, if possible, the trend of the blood pressure; obviously a rapidly falling blood pressure is indicative of more severe shock than a blood pressure which has become stabilized. There has been a tendency to underestimate the importance of the blood pressure in evaluating the degree of shock. In this respect

Preoperative Diagnosis and Triage. (The Diagnosis of Shock: The Evaluation of the Degree of Shock, contd).

the following facts are of interest: In a series of 957 cases with intra-abdominal injury the degree of shock was based upon the level of the admission systolic blood pressure. The average amount of plasma and blood which was required to accomplish resuscitation was determined for each of the four groups. It was found that the average amount of replacement therapy varied inversely with the systolic blood pressure, being greatest for the group with the lowest blood pressure. (See "The Problem of Shock Therapy in Abdominal Wounds", Table I and Figure 20 pages 124-25). It is important to remember tha the adequacy of resuscitation therapy was determined upon the basis of the clinical response in addition to the rise in the blood pressure level at the time such replacement was being carried out. Hence, it appears that in a relatively large series of cases the blood loss (as indicated approximately by the amount of replacement therapy required) is related to and within limits predictable by the admission blood pressure level. In brief, reliance in diagnosis should never be based solely upon the blood pressure nor should the importance of a low blood pressure be overlooked.

The changes and character of the pulse in patients who exhibit shock deserve some comment. The fullness of the pulse wave at the wrist should be noted carefully; its character is of importance and is of more diagnostic value than the rate, since the latter may vary over a wide range. Severe shock may occasionally be present in a patient with a relatively slow pulse and the true reduction in the peripheral blood flow is more accurately indicated by the "thready" pulse. The trend of the rate and character of the pulse is of more diagnostic importance than an isolated determination. For this reason it is important to record the pulse rate, as well as the blood pressure, at the time the patient is admitted to the hospital so that these factors may be re-evaluated from time to time.

The appearance of the patient may be modified by virtue of the fact that he has received a relatively large volume of plasma prior to admission to the hospital. Pallor may be present out of proportion to other evidences of reduced peripheral blood flow; not infrequently a peculiar waxy yellow tint is noticeable. It has been noted also that the diastolic pressure may be unusually low in patients who have received large amounts of plasma. The diastolic pressure often rises more slowly than the systolic in response to blood transfusion. In a few such cases physical signs of aortic regurgitation were sought but were found to be lacking and the changes in the diastolic pressure may depend upon the lowered blood viscosity and anemia which follow liberal plasma therapy.

APPRAISAL OF THE TYPE AND EXTENT OF INJURY

Shock and resuscitation cannot be carried out intelligently without a prompt appraisal of the number, location, and extent of the injuries. Ordinarily, as stated above, the presence of or degree of shock is

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

determined immediately and before attention is directed to the wound per se. However, physical examination must not be delayed and unless the patient is in severe shock this is best made as soon as possible. In cases in extreme shock the need for immediate resuscitation is urgent and complete examination must await improvement in the patient's condition. Even in these cases, however, examination must not be delayed unnecessarily - bleeding from an inaccessible wound may explain a poor response to transfusion therapy.

In accomplishing an adequate examination it is necessary to examine all aspects of the body. The patient's clothing is cut apart and gently removed. At this time the clothing and litter are inspected for the presence of blood and if possible the patient is moved to a clean, properly dressed litter. This can be accomplished by lifting the recumbent patient carefully and sliding the fresh litter beneath him. In the event that it is impractical to move the patient (spinal cord injuries) it may be necessary to place a clean, dry blanket beneath the patient to prevent further loss of body heat. Throughout all of these procedures the patient is constantly kept covered with a blanket to prevent chilling.

It is desirable, if possible, to make the physical examination complete before beginning intravenous therapy since this may hamper examination at a later time. The posterior aspect of the trunk and the gluteal region must always be carefully inspected; wounds in these locations are frequently overlooked. Palpation along the expected path of the missile may frequently result in detection of the missile (particularly a bullet) lying beneath the skin on the side of the body opposite the wound of entry. Also, it is very desirable to establish whether or not a perforating wound exists. Location of the missile by palpation or the definite establishment of the existence of a perforating wound may greatly simplify x-ray examination or render such examination unnecessary. This is particularly true in abdominal injuries and may result in considerable curtailment of the preoperative delay, especially during rush periods. Not infrequently the roentgen examination is repeated because no foreign body appears on the films, only for subsequent examination to reveal the wound of exit.

The detailed examination of the patient logically starts by focusing attention upon the wound itself. All wounds and the bandages covering them should be closely inspected for evidence of continuing hemorrhage. Failure to discover external hemorrhage may affect significantly the subsequent course of the patient. In appraising the probable extent of the injury it is best to visualize as nearly as possible the track of the missile and a statement by the patient as to his position at the time of wounding may be of great help in this respect. Certain

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

general types of injury will be discussed.

Wounds of the Abdomen.

In the selection and care of first priority casualties it is important to determine whether injury to a hollow viscus has resulted in soiling the peritoneum. In the usual case the location of the wound and unmistakable signs of established peritoneal irritation leave no doubt that laparotomy is required. However, the occasional case presents sufficient difficulty in diagnosis that an exploratory laparotomy may be indicated. In evaluating such cases the absence of audible peristalsis, the presence of blood in the urine, gastric contents or rectum are valuable aids. If soiling is localized to the retroperitoneal tissues or lesser peritoneal sac audible peristalsis may be misleading. Blood in the peritoneal cavity may result in sufficient evidences of peritoneal irritation so that laparotomy is necessary to rule out hollow viscus damage; usually however, abdominal rigidity and pain are less marked than when bowel contents are present within the peritoneum. Severe retroperitoneal injury alone may simulate peritonitis but in our experience such cases are infrequent. It must be remembered that previous morphine medication may alter the signs and symptoms of peritonitis.

Rectal examination may be of great diagnostic aid, particularly in wounds of the buttocks or upper thighs; too often this examination is neglected. Rigid reliance should not be placed upon the absence of blood in the gastric contents, since wounds of the stomach may be present without grossly demonstrable blood. Similarly, the absence of blood in the urine does not exclude renal or urinary tract injury.

Wounds of the Thorax.

In examination of a patient with thoracic injury attention should first be directed toward the general effects of respiratory embarrassment. Cyanosis should be searched for constantly since it is an important indication of well advanced anoxia. In patients who have suffered from severe hemorrhage the degree of cyanosis may be relatively slight even though oxygenation of the blood is seriously reduced. In many of the more critically wounded it may be difficult to determine whether shock or cardio-pulmonary dysfunction is responsible for the cyanosis. Since severe hemorrhage usually precedes severe shock, marked cyanosis is usually not attributable to shock alone but to the added factor of reduced pulmonary ventilation.

The character and rate of respirations should be evaluated; if severe dyspnea is observed its cause should be sought immediately. The influence of previously administered morphine upon respiration must

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

not be overlooked.

Examination of wounds of the chest should be thorough but not often repeated; further contamination of the pleura may occur and air enter the chest through a sucking wound. If possible it is desirable for the shock officer and surgeon to examine the wound together and thereafter the newly dressed wound need not be disturbed. At the time of examination the following facts are established: the size of the wound and the extent of damage to the chest wall; the loss of blood from the wound; the probable direction of the missile; the presence of bowel contamination in thoraco-abdominal wounds; and last but not least, the determination as to whether or not communication exists between the pleural cavity and the exterior. A sucking wound may be simulated by tangential wounds of the thoracic wall in regions where subcutaneous tissue and muscle are of considerable thickness, (e.g., in the axillary and scapular regions). Usually the true state of affairs may be established by observing the wound while the patient coughs.

Hemopneumothorax is present to some degree in practically all wounds of the chest in which the normal pleura is lacerated. The volume of blood and air which accumulates within the pleural cavity varies considerably; consequently there is wide variation in the clinical picture and one of the chief problems of the preoperative period is the diagnosis and management of hemopneumothorax. Simple observation, percussion and auscultation will provide important information and should not be neglected. The signs vary depending upon the predominance of blood or air in the pleural cavity but not infrequently the condition of the patient or the presence of other wounds restricts the usefulness of physical diagnosis. Mild degrees of subcutaneous emphysema are common, particularly if marked adhesive pleuritis and/or bronchopleural fistula are present. Pressure pneumothorax, though relatively uncommon, is usually not difficult to recognize. Characteristically, dyspnea and cyanosis are severe; the trachea and cardiac impulse are shifted toward the opposite side; often the patient gives a history of increasing dyspnea prior to admission. Except for evidences of mediastinal shift a similar picture may be seen in large pneumothoraces. In both instances collapse of the lung may be incomplete in areas in which there has been considerable trauma to the pulmonary parenchyma. One should be cognizant of this fact as well as search carefully for evidence of intrapleural adhesions in the interpretation of roentgenograms of the chest in such cases.

Aside from its therapeutic value, thoracenthesis is capable of supplying helpful diagnostic information, particularly when other measures prove to be inconclusive. By this means the amount of blood

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of injury, contd).

and air in the chest may be determined within fairly close limits. The continued removal of air indicates the presence of a significant broncho-pleural fistula and the need for establishing continuous decompression of the pleural cavity. Once this has been instituted (by means of a needle or preferably a catheter in the second anterior intercostal space) the amount of air lost through the water seal affords a means of evaluating the size of the broncho-pleural fistula. Thoracentesis is also helpful in that the removal of blood and air may simplify the interpretation of subsequent roentgen films. Furthermore, in rare instances gross and microscopic examination of the aspirated fluid may definitely establish the presence of severe bacterial contamination in patients that have been wounded for many hours.

When the pulmonary parenchyma is injured varying degrees of hemorrhage may occur depending upon the nature and extent of the trauma and the type and caliber of the vessels involved. Injury to a hilar vessel is of grave significance; certainly the majority of patients with such injuries become exsanguinated or are asphyxiated by massive intrabronchial hemorrhage before reaching a forward hospital. Even moderate degrees of hemorrhage into the bronchi are important because of the likelihood that atelectasis of a considerable portion of the lung will result. In the presence of hemopneumothorax typical signs of atelectasis may be absent or greatly modified. Evidence of a shift of the mediastinum toward the affected side is important but it is probable that a considerable degree of atelectasis may exist without producing a shift in the trachea or cardiac impulse. If signs of decreased pulmonary ventilation persist after thoracentesis one should suspect the presence of atelectasis. Severe degrees of atelectasis may be encountered following maxillo-facial wounds or cervical wounds with injury to the respiratory passages. Similarly bronchial obstruction and atelectasis may occur in the unconscious patient following the aspiration of vomitus.

It is important if possible to establish the presence of mediastinal involvement in all thoracic injuries. This is best accomplished by visualizing the path of the missile with the aid of x-ray studies. Isolated injury of the esophagus is uncommon and substernal pain upon swallowing may be the only indication of esophageal injury. Evidence of cardiac injury may be deduced from the type of pain, cardiac irregularity or widening of the pericardial shadow by x-ray. Often an accurate diagnosis of a wound of the heart is difficult to establish and the greatest aid is to be derived from the projected course of the missile. (See section dealing with Cardiac Wounds, page 463).. Mediastinal emphysema has not proven to be of great importance in the experience of thoracic surgeons of this Group; concomitant laceration of the mediastinal pleura may prevent the accumulation of a large volume of air just as the majority of pericardial

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

lacerations prevent the development of cardiac tamponade. If a major bronchus is lacerated near the hilus of the lung one may suspect a rapid accumulation of air within the pleural cavity and pressure pneumothorax may follow within a relatively short time.

Thoraco-Abdominal Wounds.

All wounds of the chest below the seventh interspace posteriorly and the fourth rib anteriorly should be considered as potential thoraco-abdominal wounds. However, perforation of the diaphragm may occur from missiles which enter via the gluteal or shoulder region but in the average case the wound of entrance lies in the lower half of the chest. Very uncommonly the diaphragm is perforated from below.

It is of utmost importance to establish the presence of intra-abdominal injury in all thoracic cases and such a diagnosis may be rendered difficult by virtue of pain arising in the lower thoracic wall. The usual diagnostic measures are employed as discussed above. In such cases adequate roentgen studies are invaluable in arriving at a correct diagnosis. Re-examination of the patient following intercostal nerve block may be helpful since abdominal rigidity due to peritonitis remains unchanged whereas pain and voluntary muscle spasm due to thoracic wall injury may be considerably reduced. However, too much emphasis upon the effect of nerve block may lead to erronous conclusions. The presence of pain referred to the shoulder is important evidence of injury to the diaphragm; such pain is very infrequent in simple thoracic wounds, but it may be absent even though injury to the diaphragm is found subsequently at operation.

If, after careful study, it cannot be established definitely that intra-abdominal injury does not exist, operative exploration is indicated.

Wounds of the Spinal Cord.

In wounds of the trunk or cervical region the examiner should always be cognizant of the possibility of spinal cord injury. Unless one is sufficiently aware of this possibility it may easily be overlooked in the pre-occupation with other more obvious injury. Often simple inspection of the patient will indicate the probable diagnosis; priapism, unusually full superficial veins of the lower extremities or loss of abdominal respiratory motion are signs of importance. Absence of deep tendon reflexes and loss of sensation and motor activity below the level of injury serve to establish the diagnosis. The level and completeness of the lesion should be determined prior to operation. Also, the patient should be questioned as to the rapidity with which paralysis ensued after injury; in the vast majority of cases loss of function will be immediate but in rare cases delayed paralysis may indicate that compression

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

of the cord has occurred subsequent to the initial injury.

Maxillo-Facial Wounds.

All but the slightest maxillo-facial injuries are commonly associated with considerable oral or nasopharyngeal hemorrhage and aspiration of blood must be prevented, particularly in the stuporous or comatose patient. All such patients should be evacuated in the prone position with the face slightly lower than the trunk. In both maxillo-facial and cervical wounds severe tracheal obstructions may occur with alarming rapidity and the need for immediate tracheotomy must be evaluated promptly, particularly in injuries of the hypopharynx or larynx. The source and degree of hemorrhage deserve careful attention.

Wounds of the Extremities.

Major vascular injuries are common in extensive wounds of the extremities and the examination should determine initially the presence or absence of a tourniquet and whether or not active bleeding is in progress. Likewise, one must determine the state of the circulation of the extremity. The character of the peripheral pulse in the injured limbs should be compared with that of the normal extremity; cyanosis, edema, induration and the response of the skin circulation to localized momentary pressure are points worthy of notice. The examination should establish the fact that adequate splinting of fractures has been accomplished and that no constricting bandages encircle the extremity. Nerve injury should be assessed as completely as possible during the preoperative examination, particularly in wounds which involve the upper extremity. This is equally true in wounds of the pelvic or shoulder girdle which may result in nerve or nerve plexus injuries.

Cranial Injuries.

Wound shock is not often a major problem in those patients with cerebral injuries who live to reach the forward hospitals. The immediate threat to life is determined not by failure of peripheral circulation but by the extent of brain damage. Often it is well to keep such patients under observation in the Field Hospital for a short time to establish definitely the fact that no rapid increase in intracranial pressure is occurring. However, evacuation of the patient to the care of a neurosurgeon (Evacuation Hospital) must not be delayed unnecessarily. In our experience signs of an appreciable increase in intracranial pressure are not common. In the stuporous or comatose patient aspiration of vomitus may occur with grave embarrassment of pulmonary function. Likewise, severe cerebral injury may occasionally produce pulmonary vasomotor changes which result in pulmonary edema indistinguishable from that caused by blast injury of the lungs.

Preoperative Diagnosis and Triage. (Appraisal of the Type and Extent of Injury, contd).

In the examination of cranial wounds great care must be exercised to prevent further contamination. Time rarely permits exhaustive neurosurgical examination prior to evacuation of the patient from the Field Hospital; however, when important localizing signs are observed these should be noted upon the patient's record.

In ocular injuries the visual defect should be evaluated as well as possible. The presence of blood in the anterior chamber should be noted because of the indication for the prompt use of mydriatics in such cases to prevent the formation of synechiae. Again, evacuation of the patient for expert ophthalmological care should be accomplished without delay unless other injury requires prompt initial surgery.

Blast Injury.

The organs which are most commonly injured as the result of concussion from a nearly explosion are the lungs and hollow viscera. The brain is not believed to suffer damage from the blast wave (4) but traumatic concussion may result if the patient is thrown forcibly against a stationary object. Examples of solitary blast injury are infrequent - usually the soldier sustains shell fragment wounds at the same time.

Patients suffering from pulmonary blast injury may experience moderate dyspnea and tachypnea may be present. Scattered moist rales may be heard throughout the chest and small amounts of serosanguinous fluid may be expectorated. Cyanosis may be present, usually it is not marked but is often not completely relieved by the inhalation of 90-100% oxygen. It is important to remember that pulmonary fat embolism (following fractures and, less frequently, extensive trauma of adipose tissue) may be indistinguishable from pulmonary blast injury.

Lacerations of the bowel may result from blast injury or extensive necrosis of the bowel wall may occur. (See Case No. 8 page 48 "Resuscitation and Preoperative Care of the Severely Wounded"). In the patient who has received previous morphine medication and in whom no abdominal wound is present intra-abdominal blast injury may easily be overlooked.

In patients suffering from partial or complete traumatic amputation of the foot due to mine explosion one may rarely observe extensive edema of the entire leg. This appears to be due to vascular damage caused by direct concussion of the limb and not by the effect of the blast since the opposite leg may escape injury completely.

Figure 2

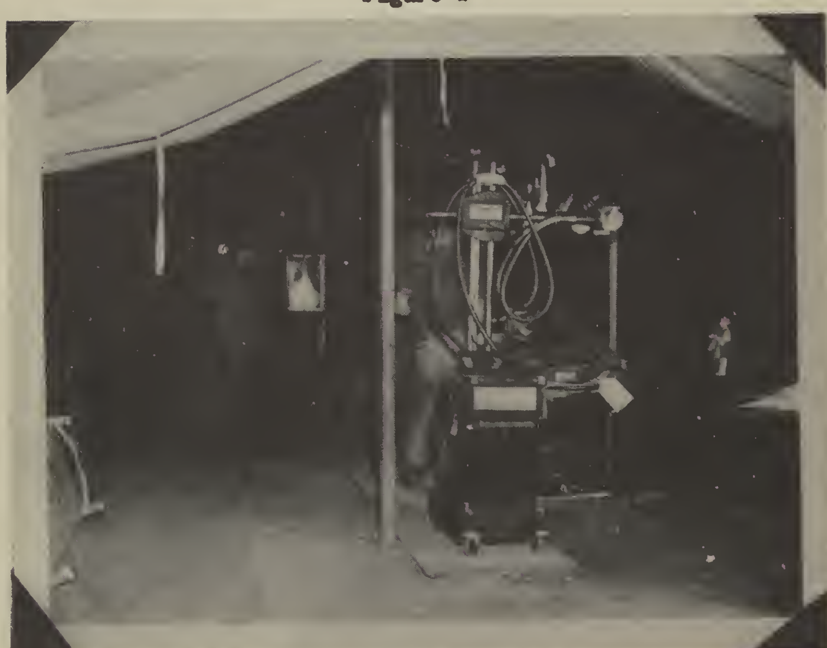

Figure 3

Figures 2 and 3 Laboratory and X-ray Facilities
in Field Hospital

Preoperative Diagnosis and Triage.

THE USE OF ROENTGENOGRAPHY IN DIAGNOSIS

Conclusive diagnostic studies may be impossible without adequate bi-directional roentgenograms. Roentgen examination should be accomplished as soon after admission as possible, although often, some degree of replacement therapy will be required first. However, if the patient shows little or no evidence of shock films are easiest to obtain prior to the initiation of replacement therapy. In patients who require vigorous shock therapy roentgenography is usually postponed until immediately prior to operation.

In attempting to localize foreign bodies it is the duty of the shock officer to see that adequate antero-posterior and lateral films are made. Films should include a considerable view above and below the wound of entry; in wounds of the mid-trunk it often saves time to first localize the foreign body by means of antero-posterior films of the chest and abdomen (including upper gluteal region); the lateral exposure may then be taken over the location of the fragments. Adequate lateral films of the upper thigh and gluteal regions may be difficult in the presence of a leg splint and it may be necessary to tilt the tube and lift the gluteal region above the litter bar by providing a supporting platform from below. Placing the patient on a clean litter will greatly reduce the incidence of artifacts due to foreign material in the blankets or on the litter.

Occasionally bullets or shell fragments may fall free in the chest or peritoneal cavity and appear in unexpected positions. A foreign body may overlie the heart in an antero-posterior film and not be seen in the lateral; when this occurs one should suspect a foreign body in the heart or pericardium, cardiac motion preventing its visualization in lateral films. In frontal films heavy penetration frequently aids in visualizing cardiac foreign bodies.

Diagnosis in the wounded man is ordinarily much more direct and less detailed than in civilian practice and much less emphasis is placed upon the patient's history. However, questioning the patient relative to a few simple facts may afford considerable help. Initially, it is often well to direct one's attention to the chief complaint of the patient and determine the location and severity of the pain which he may experience. A few questions have already been mentioned in connection with the various types of wounds. Additional facts may be established such as: corroboration of data which appear on the patient's field medical tag; the exposure to cold; the presence and amount of hemoptysis after injury; the severity of hemorrhage; the occurrence and severity of vomiting; the time of the last meal prior to injury; the presence of previous upper respiratory

Preoperative Diagnosis and Triage. (The Use of Roentgenography in Diagnosis, contd).

infection, etc.

The medical tag should be carefully checked to determine the amount of morphine the patient has received and the time it was given, as well as the amount of plasma which has been administered.

TRIAGE

Triage is simply the process of coordinating the time and place of the patients' initial surgical care with the severity of the injury.

By virtue of its location near the combat area, the Field Hospital Unit is in the most nearly ideal situation to care for the severely wounded - the "non-transportable" casualties whose life would be endangered by further evacuation to the rear. Consequently the Field Hospital receives from the Divisional Clearing Station those patients which fall into one or more of the following categories: (1) those in which injury has resulted in severe physiological disturbances which constitute an immediate threat to life; (2) patients in which overwhelming infection will soon jeopardize life. Specifically, the following types of wounds require initial surgery or resuscitation in the forward area: patients suffering from shock due to severe or progressing hemorrhage; patients with respiratory distress due to open wounds of the chest or maxillo-facial wounds with obstruction of the respiratory passages; wounds of the abdomen; compound fractures of long bones; traumatic amputations; major injury to the vessels of an extremity or extensive trauma to soft tissue which may be followed by anaerobic myositis (gas gangrene) and rarely, cranial injuries with increasing intracranial pressure.

In order that the limited personnel of a Field Hospital may deal exclusively with the care of such casualties it becomes mandatory that patients with lesser wounds not be sent to such installations but be evacuated from the Clearing Station directly to the rear. Occasionally it may be impossible to determine the extent of the patient's injury in the Clearing Station and it becomes necessary to refer such casualties to the Field Hospital for roentgen examination and more detailed diagnostic study to determine whether or not the injury is of such a nature as to warrant initial surgical care in the divisional area. The establishment of the presence of intra-abdominal injury is usually the information needed but this practice may be carried to extreme lengths particularly when Clearing Station personnel are unfamiliar with war wounds and the task of the Field Hospital. The facilities of such a hospital may be greatly overburdened should the Clearing Station personnel regard the Field Hospital roentgen unit as a screening unit for a large number of patients whose wounds are relatively mild.

Preoperative Diagnosis and Triage. (Triage, contd).

Nevertheless, it is often possible to establish the fact that a casualty is evacuable after a brief observation in the shock ward, thus allowing surgical teams to concentrate upon the true priority casualties. Likewise, stabilization of the patient may be attained which will allow his prompt evacuation if the threat of severe infection does not exist. This is particularly true of single thoracic injuries. We have continually been able to evacuate before operation as high as 50% of all uncomplicated thoracic cases by the use of thoracentesis, intercostal nerve block and transfusion therapy, all of which can be accomplished in a relatively short time, and often replacement therapy is not required. Such preoperative triage, therapy and prompt evacuation are particularly important during rush periods when the number of very severely wounded casualties may cause prolonged preoperative delay for casualties with less severe injury. Obviously criteria for evacuation from the preoperative ward of a Field Hospital depend somewhat upon the inflow of casualties, the proximity of the Evacuation Hospital, etc. During relatively quiet periods patients may be operated upon in the most forward hospital who would often be evacuated to the rear during busy periods.

Among those patients whose injury requires prompt surgery the principles of triage or selection for priority of operation still holds. In general, those patients with the most severe wounds deserve priority for surgical care; this is particularly true in wounds of the abdomen and those in which continuing hemorrhage is present which cannot be controlled by ordinary first aid measures. (See Case #7*, page 47). The following example illustrates this point: assume that two patients have responded well to shock therapy; one suffers from a simple thoracic wound, the other from a thoraco-abdominal wound, - - obviously the thoraco-abdominal wound should receive priority for operation if, as often happens, operating facilities will only accomodate one patient at any given time.

In establishing the relative individual priority among several patients awaiting surgery it is necessary to utilize one's diagnostic acumen to the utmost and from time to time the clinical improvement (or more exactly, lack of improvement) must be evaluated in relation to all clinical data at hand. Nothing so greatly taxes the smooth functioning of a shock ward as the simultaneous admission of six or eight severely wounded patients to a hospital whose operating facilities will accomodate only two to three patients at a time. Expert judgment is required to evaluate promptly the severity and type of injury in each case so that replacement therapy as well as the timing of operation may be accurately adapted to the needs of the patient. In such instances the close diagnostic collaboration of the surgeon and the shock officer may be of inestimable value in determining the status of the patient as well as his therapeutic needs. During such rush periods nothing will supplant

* "Resuscitation and Preoperative Care of the Severely Wounded".

a prompt and thorough physical examination, the discovery of an obvious perforating wound of the abdomen will allow operation to be started without further delay. Attention may then be focused upon patients with more obscure injuries, shock treatment administered and diagnositic studies carried out so that as soon as one operation is completed another patient will be ready for surgery.

Every attempt should be made to maintain continuity of care. Preferably the surgeon should acquaint himself with the problems presented by the particular patient upon whom operation is to be performed. He should receive the fullest possible aid from the officer in charge of preoperative care. It is well for the surgeon and the shock officer to review together the roentograms and other laboratory studies pertaining to the patient.

SUMMARY

Diagnostic problems encountered in the preoperative care of severely wounded men may be simple or exceedingly complex. Through study of the injured man an attempt is made to evaluate the effects of injury upon normal physiological mechanisms as well as to allow intelligent planning of operation through close attention to the wound itself and the structures which have been injured.

In military surgery the large number of casualties makes it necessary to classify patients according to the severity of their wounds and to afford initial surgical care as the severity or injury indicates. Not only are triage and selection of cases applicable throughout all echelons of medical installations but also within individual forward hospitals priority for surgical care is based upon the severity of the injury and the immediate or delayed consequences thereof. Should such selection of patients be poorly managed much of the advantage of the hospital's forward location may be lost. The preoperative ward should be run in such a way that a steady flow of patients to surgery is assured without unnecessary delay between operations. Continuity of professional care must be obtained by free liaison between the surgeon and the officer in charge of resuscitation and preoperative care.

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RESUSCITATION AND PREOPERATIVE CARE OF THE SEVERELY WOUNDED

RESUSCITATION AND PREOPERATIVE CARE OF THE SEVERELY WOUNDED

The problems of preoperative diagnosis have been discussed in a previous section* dealing with the local and general effects of severe injury upon the wounded man. It is well at this point to deal briefly with wound shock in the light of present concepts as to its pathogenesis. Factors which are important in the production of wound shock will be discussed and finally, the resuscitation of the critically injured man and his preparation for initial surgery will be outlined.

THE PATHOGENESIS OF WOUND SHOCK

The intelligent management of traumatic shock in the war wounded demands that emphasis be placed upon certain well-established facts of practical importance. Theoretical or highly controversial ideas must ofen be disregarded in the face of the exigencies of war and it is not pertinent to discuss here the many theories related to the pathogenesis of the peripheral circulatory failure which follows injury. It is generally agreed that the single most important factor in the production of traumatic shock is the loss of whole blood or plasma from the vascular bed in the traumatized area. The acceptance of this fact is based upon the outstanding experimental work of Blalock and associates (1) and Parsons and Phemister (2). More recent work has confirmed the validity of these impressions in man. Richards, in summarizing this work, offers convincing proof that the underlying disturbances in shock are a failure of return of blood to the heart with diminished blood flow and tissue anoxia (3).

Detailed studies of wounded men have been carried out in the Mediterranean Theater of Operations (4). A close correlation was found between the blood loss and the degree of shock which follows injury; the important factor in the production of shock is the character of the wound and especially its relation to hemorrhage.

The success of plasma and blood replacement in the therapy of shock during the present war affords further conclusive evidence that a reduction in the circulating blood volume is of fundamental importance in the production of wound shock. Likewise, it has been shown (see "The Problem of Shock Therapy in Abdominal Wounds", Table I and Figure 20 , page 125) that the volume of blood and plasma required in resuscitation increases directly as the severity of shock increases. These findings and those cited above offer strong support to the contention that the most important factor in the reduction of blood volume and the production of shock is the loss of fluid from the site of injury.

It must always be remembered that the loss of fluid from the vascular bed is rarely a simple process. In battle casualties the loss of whole blood from the site of trauma is of outstanding importance and is usually

* "Preoperative Diagnosis and Triage" (page 7)

the predominant initiating factor in such injuries. However, particularly in wounds of the abdomen, large amounts of fluid may be lost through exudation and transduction from serosal surfaces. Likewise, the loss of plasma or plasma components about the periphery of a wound or in the wall of the bowel due to mechanical or chemical irritation constitutes an additional source of fluid loss. Also, considerable fluid may be lost by vomiting, or paralytic ileus may interfere with the reabsorption of fluid from the large bowel in the presence of diffuse peritoneal contamination. In attempting to evaluate any causative factor in shock it is imperative that associated fluid loss be critically assessed (5). These and other factors will be discussed subsequently in more detail.

As the effective circulating blood volume is reduced through blood or plasma loss, certain physiological responses are called into play which more or less determine the clinical appearance of the wounded man. Chief among these processes is the action of a strong vasoconstrictor mechanism which serves to divert blood from the skin and muscles and certain organ systems to the central circulation (3). Thus the arterial blood pressure is maintained for some time in the face of blood loss but at the expense of the peripheral circulation, and the skin becomes pale and cold, superficial veins are constricted and weakness may be severe. Evidence of poor cardiac filling and decreased stroke volume may be found in the rapid, thready radial pulse. As the effective circulating blood volume is further reduced the blood pressure falls in spite of intensive vasoconstrictor activity, and the central circulation is decreased.

Several investigators have insisted that hemoconcentration is an essential and fundamental factor in traumatic shock (6). Our observations in wound shock do not support this contention for the following reasons: 1) The vast majority of battle casualties who exhibit unmistakable signs of shock show normal or low hematocrit levels. This experience is in accord with the findings of Lalich (7) and the Board for the Study of the Severely Wounded (4). 2) In the most severe degrees of shock the lowest hematocrit levels (for example 15-20 volumes percent) are often observed due to spontaneous hemodilution and the previous administration of plasma. 3) Finally, the shock that may be present or prove fatal in the immediate postoperative period is consistently associated with a low rather than a high hematocrit in spite of the liberal transfusion of whole blood.

It must be remembered that the level of the hematocrit which is observed after injury is the resultant of the action of several factors. Following hemorrhage it remains within normal limits until hemodilution occurs; as extracellular fluid enters the blood stream the hematocrit falls. The predominant importance of hemorrhage in the pathogenesis of wound shock is indicated by the factors which were mentioned above. We believe that an elevation of the hematocrit (as seen in burns, crushing

or contusion injury and in the presence of diffuse peritoneal contamination) is simply an indication that a greater amount of plasma than of whole blood has been lost into the traumatized area.

In the literature dealing with traumatic shock reference is often made to "irreversible shock"; a condition characterized by a generalized increase in capillary permeability which renders replacement therapy ineffectual, inasmuch as such fluid is rapidly lost from the vascular bed. This "negative response to transfusion" is construed to constitute evidence for generalized capilary damage which occurs after shock has existed for some time. The work of Stead (8) casts serious doubt that an increase in capillary permeability occurs distant to the area of trauma except as an agonal change. More and more evidence is being accumulated that injury to various organs is the deciding factor as to whether or not resuscitation from severe and prolonged shock can be accomplished (4)(9)(10). _A priori_ it would be supposed that cerebral function would suffer the most severe damage as a result of the anoxia of shock. However, experience has shown that the cerebral circulation tends to be maintained at a fairly satisfactory level until the end. In young healthy adults moderate clouding of the sensorium, mild disorientation and amnesia may be observed fairly frequently in severe shock. Coma and signs of focal brain damage are rare except in the moribund patient and even in these patients it may be possible to exclude other causative factors (fat embolism, traumatic concussion, etc.).

Lauson and associates (10) have shown that a marked reduction in renal blood flow occurs in shock, and they present evidence that prolonged shock may result in renal failure. Similar evidence has been derived from the study of posttraumatic renal insufficiency in this Theater (4). These findings strongly suggest that shock may produce renal ischemia of such severity that irreversible renal damage may result if shock is of sufficient duration. Some evidence exists that severe shock may result in cardiac damage in rare instances. Burnett, Bland and Beecher (11) found electricardiographic abnormalities in five out of 30 cases studied within a short time after injury. Post-mortem evidence of cardiac failure may be found in patients who have exhibited severe degrees of shock; however, such findings may depend upon renal failure and hydremia rather than upon damage to the heart _per se_. Kihlsteadt and Page (12) have reported evidences of disturbances in cardiac function in terminal hemorrhagic shock in dogs.

The foregoing discussion does not imply that a single causative factor suffices to explain all aspects of the pathogenesis of traumatic shock, nor that the problem of shock is completely understood. Our knowledge is far from complete in many respects, e.g.: The mechanisms by which severe infections bring about peripheral circulatory failure; the local vascular

responses to diffuse peritoneal contamination; the importance of fat embolism in the production of shock and early death; the cellular metabolic changes which result from prolonged shock. However, in preoccupation with unknown factors the practical application of accepted concepts must not be neglected.

EVALUATION OF THE CAUSATIVE FACTORS IN WOUND SHOCK

We believe the following to be the most important causes of the shock which occurs in battle casualties:

1. Hemorrhage from the traumatized area.

2. The loss of plasma or plasma components in the traumatized or contaminated area.
   a. Exudation or transudation from inflamed serous surfaces under the influences of mechanical and chemical trauma and beginning infection.
   b. The loss of fluid into the tissues adjacent to the area of greatest trauma or due to the action of chemical irritants.

3. Additional factors related to certain types of injury.
   a. Cardiopulmonary dysfunction associated with wounds of the thorax.
   b. Loss of vasomotor reflexes associated with lesions of the spinal cord.
   c. Fat embolism resulting from trauma of bone or adipose tissue.

4. Blast injury of lungs and abdominal viscera.

5. Overwhelming infection.

Hemorrhage from the Traumatized Area

In severely wounded battle casualties, hemorrhage is by far the most important factor in initiating the circulatory disturbances which characterize shock. Furthermore, when severe shock is observed, it may be assumed that a relatively large volume of blood has been lost. Blalock (13) has shown that hemorrhage is capable of producing shock in dogs which is closely related to the shock produced by other means. This does not imply that other factors may not be involved, but hemorrhage per se, if severe, will produce all the clinical and physiological manifestations of severe traumatic shock.

The rate at which blood is lost is important in determining the clinical manifestations of hemorrhage. Blood loss may be so rapid that an immediate reduction in the circulating blood volume occurs and shock (aside from syncope) is manifest promptly. If on the other hand hemorrhage is less rapid, the circulation may remain at a relatively normal level for some time and manifestions of shock fail to appear until a decrease in the circulating blood volume occurs. The severity of the hemorrhage bears an important relation to the evacuation of battle casualties; severe hemorrhage that occurs rapidly will greatly shorten the time during shich successful shock therapy may be accomplished. If prompt evacuation cannot be effected death may occur before such patients reach the Field Hospital. Conversely, if severe or profound shock is present within one to two hours after injury it may be assumed that severe hemorrhage has occurred as a result of the injury.

Blood loss has been determined in various types of wounds (4). The following wounds are in order of increasing blood loss: abdominal wounds, extremity wounds without fractures, traumatic amputation; thoracic wounds, and extremity wounds with major compound fractures.

<u>The Loss of Plasma or Plasma Components in the Traumatized Area</u>

a. Exudation and transudation from inflamed serous surfaces under the influences of mechanical and chemical trauma and beginning infection.

The local loss of fluid into a contaminated peritoneal cavity comprises an important means whereby fluid is lost from the blood stream with a consequent reduction in the circulating blood volume. When contamination is widespread and the contaminating agent highly irritating, this loss may be excessive. The extremely high mortality which has been observed in association with contamination of a pleural cavity by stomach or bowel contents offers further evidence of the importance of contamination and infection in the production of shock. Such patients often die within a short time after operation with clinical evidence of shock in spite of the fact that replacement therapy brought about a satisfactory response during the preoperative period. Likewise, the role of diffuse peritoneal contamination in increasing the severity of shock in the presence of evisceration of bowel has proven to be of interest. When simple evisceration exists without peritoneal contamination, shock is often surprisingly mild in degree and the response to therapy is much more prompt and sustained than when there is coexisting diffuse peritoneal contamination. See cases numbers 1, 2 and 3. It is evident that the degree and extent of injury, which includes peritoneal contamination, is of more importance in determining the degree of shock than is the simple mechanical existence of eviseration. (See section on "Traumatic Evisceration", page 162 .)

Changes which occur in the splanchnic capillary bed due to irritation appear to be of some importance in reducing the effective circulating blood volume in those cases with severe peritoneal contamination. Mann (14) pointed out that mechanical trauma to the bowel is associated with an increased capacity of the splanchnic vascular bed and observations at operation in cases with diffuse peritoneal contamination indicate that a considerable volume of blood may be pooled in dilated and engorged venules and capillaries. Furthermore, this factor may be increased during operation through the necessary handling of the bowel which attends surgery.

b. The loss of fluid into the tissues adjacent to the area of greatest trauma or due to the action of chemical irritants.

The swelling adjacent to a wound is partially due to the presence of serous fluid which has leaked from vessels which have been damaged but have not been torn asunder. Similar loss occurs into the wall of the bowel under the influence of the irritation of peritoneal contamination or bacterial growth. In war wounds extensive laceration and mangling of the bowel may occur and serous fluid (as well as blood) loss into such tissues may be considerable. Strangulation of the blood supply has proved to be a very uncommon cause of segmental edema and necrosis of the bowell wall even in cases with evisceration.

In paralytic ileus which follows peritoneal contamination or infection, the failure of the small bowel secretions to reach the colon prevents the normal reabsorption of water from the bowel. Actually, moderate dehydration may exist whether vomiting has or has not occurred.

From the foregoing discussion it may be seen that changes which occur within the contaminated peritoneal cavity following injury favor the loss of plasma or fluid from the blood stream. Thus, if preceding or concomitant hemorrhage is slight, these factors may lead to hemoconcentration. In battle casualties the tendency towards hemodilution secondary to hemorrhage must always be remembered; only an elevated hematocrit will be of aid in evaluating the presence of, or the degree of plasma loss. A similar tendency for the hematocrit to be elevated is observed in burns, crush injuries and severe contusive injury. In massive soft tissue infections (anaerobic myositis or cellulitis) the hemoconcentrating effects of trasudation and exudation are often offset by previous hemorrhage.

Additional Factors Related to Certain Types of Injury

Aside from hemorrhage and the loss of blood components from the site of injury, other factors may be on considerable importance in maintaining shock or increasing the severity thereof. The presence of multiple wounds may invoke deleterious action of several factors upon the state of the wounded man; the degree of shock being influenced by the summation of these factors.

a. Cardiopulmonary dysfunction associated with Wounds of the thorax.

The insult imposed upon the circulation by open wounds of the chest, hemopneumothorax and pressure pneumothorax may greatly increase the degree of peripheral circulatory failure. If severe, these factors may be of primary importance in the production of shock due to the loss of normal cardiorespiratory function of the thoracac cage which results in decreased cardiac filling and decreased blood flow. Hemorrhage is frequently severe in thoracic injuries; in combination with the factors just mentioned it may be responsible for profound shock. When hemopneumothorax, atelectasis and pulmonary injury interferewith adequate oxygen exchange severe degrees of anoxia may result; if severe shock also exists the effects constitute an immediate threat to life. The effect of pleural contamination has been mentioned. Occasionally severe anoxia may be associated with an elevated blood pressure even though unmistakable signs of shock are present.

b. Loss of vasomotor reflexes associated with lesions of the spinal cord.

Some interesting observations have been made upon patients with traumatic lesions of the spinal cord. These patients have been observed to exhibit hypotension which is not analogous to that seen in shock. However, lack of understanding of the circulatory dynamics in such cases may lead to mistakes in therapy -- particularly excessive delay of operation and overtransfusion. The level of the blood pressure is usually only moderately or slightly depressed. In general, the higher the lesion of the spinal cord the lower the blood pressure level; if considerable hemorrhage has also occurred the blood pressure may be very low. One of the outstanding characteristics of the blood pressure is the difficulty with which it can be restored to a level which approaches normal. Fullness of the peripheral veins, particularly of the lower extremities may be striking. It appears that these disturbances in circulatory dynamics which are observed in such patients are due to the loss of reflex vasomotor activity below the level of the lesion as well as to the decrease in venous return due to muscle paralysis. In high spinal cord lesions the efferent limb (thoracolumbar sympathetic outflow) of the carotid sinus and aortic body vasomotor reflexes become inactive due to interruption of the reflex at the level of the lesion (15). The response to hemorrhage in these cases is similar to that which is seen in the experimental animal following sympathectomy (16).

c. Fat embolism due to trauma of bone or adipose tissue.

The importance of fat embolism in the pathogenesis of shock is poorly understood. Studies of tissues after death indicate that fat emboli are frequently observed in the pulmonary vessels following severe

trauma. The relation of bone trauma to fat embolism is well recognized, but injury to soft tissues may result in fat embolism (17). In a series of 51 autopsies performed by a member of this Group in the Field Hospitals, the microscopic reports have been reviewed. In 31 cases in which sections of lung were examined there were 17 cases (54.8%) of pulmonary fat embolism. In five cases (16%) the embolism was described as "severe" by the pathologist; in five additional cases, as "moderate". It is of interest that severe embolization was noted as soon as seven hours after injury; the longest survival in a patient with moderately severe fat embolism was approximately 130 hours. It is noteworthy that respiratory difficulties were common, that in the patients who died a short time after injury there were indications of central depression of respirations and that pulmonary edema and congestion were more outstanding in these patients who lived upwards to 130 hours. It is not implied that fat embolism was the sole cause of death in these cases.

Thus, pulmonary fat embolism appears to be common in battle casualties. It seems, however, that the pulmonary circulation prevents fat from reaching the systemic arteriolar bed except in the instances of severe embolization. In these cases it appears that fat emboli were instrumental in producing shock and death. (See Case 9.)

The clinical recognition of fat embolism has been difficult. Methods for demonstrating neutral fat in the urine and sputum were not available and the usefulness of these methods in the diagnosis of fat embolism is not known. In a patient who responds slowly to shock therapy or exhibits a sudden fall in blood pressure (perhaps with evidences of central nervous system involvement) the tentative diagnosis of fat embolism may be made when other factors fail to explain the observed clinical picture. In the absence of blast injury, persistent cyanosis which is not relieved by 100% oxygen therapy may be indicative of pulmonary fat embolism; scattered fine or medium moist rales may be due to pulmonary fat embolism but are often of little differential value. Patients with severe fractures are particularly liable to exhibit a fall in blood pressure following movement of the fractured extremity; fat embolism may offer a partial explanation of this fact, although the changes may be so prompt as to suggest a neurogenic or syncopal feature.

Blast Injury to Lungs and Abdominal Viscera

Involvement of the lungs has proven to be more common than the involvement of other organs in our experience, but cases have been seen in which the major damage due to blast has involved the abdominal organs. (Case No. 8) Clinically, it may be impossible to differentiate the effects of pulmonary blast injury from those of severe pulmonary fat embolism. Associated blast injury may render successful shock therapy difficult but the pathological physiology of shock in blast injury is not

completely understood. In many instances the predominant injury appears to involve the smaller blood vessels in the traumatized area, though lacerations of the bowel may be produced.

Overwhelming Infection

The most severe infections which occur as the result of wounds are anaerobic myositis (gas gangrene), anaerobic cellulitis and diffuse peritonitis.

In the severe lacerating and destructive wounds of modern warfare anaerobic infection may occur relatively early and progress rapidly in ischemic and devitalized muscle. Evidences of peripheral circulatory failure form a common part of the clinical picture in such cases and are attributed to the exotoxins which are produced by the invading organism. However, the exact influence which these toxins exert upon the cardiovascular system is not completely understood. Discussion now appears to be centered upon the question as to whether or not the heart or the peripheral vascular bed is primarily involved. Whatever the exact cause proves to be, experience has shown that the peripheral circulatory failure so induced responds poorly to replacement therapy. The control of shock in such cases depends upon early and adequate surgery -- not upon transfusion alone.

The loss of fluid (exudate or transudate) into the contaminated peritoneal cavity has been discussed; further aspects of the relation of shock to peritoneal soiling and peritonitis will be discussed in the section, "The Problem of Shock Therapy in Abdominal Wounds", page 122 .

THE MANAGEMENT OF SHOCK IN FORWARD AREAS

The Use of Blood and Blood Substitutes

Preoperative replacement therapy attempts to restore circulatory dynamics to a level which will permit the successful accomplishment of initial surger; without such preparation, the scope of forward surgery would be greatly limited.

The disturbances in circulatory dynamics which characterize wound shock have been discussed. At the present time the most important factor in the initiation of these disturbances is believed to be the loss of blood or plasma from the vascular system at the site of injury. The rationale for the present transfusion therapy of shock is based upon this concept. The aim of shock therapy is to restore the circulating blood volume by returning to the blood stream those constituents which have been lost as the result of injury. It is furthermore important to institute replacement therapy as soon as possible after injury so as to minimize the deleterious effects which severe shock imposes upon the wounded.

Resuscitation and Preoperative Care of the Severely Wounded (The Management of Shock in Forward Areas)

The prevention of severe shock by early replacement therapy is much more likely to be successful than is the treatment of shock in its severe or late stages (13). Therefore, forward medical installations are in the ideal situation to provide treatment for shock at the time when the greatest benefit will be derived therefrom. To carry out such therapy adequately it becomes necessary to provide large quantities of citrated blood and plasma for use in the forward hospitals.

The recognition of the importance of early and complete replacement therapy in shock has resulted in two important advances in military surgery, namely: (1) The provision of adequate quantities of lyophilized plasma to all medical echelons, particularly those in the immediate combat zone. (2) The establishment of blood banks and facilities for distributing large quantities of citrated blood to forward hospitals. Without such help, the adequate therapy for shock in the severely wounded would have been virtually impossible.

The surgery of major trauma under field conditions is, at best, an exacting problem; in the patient suffering from shock, initial surgery is greatly handicapped. The object of adequate shock therapy is to minimize as much as possible the restrictions which severe traumatic shock, impose upon the surgeon. Of overwhelming importance in attaining this end is the transfusion of reconstituted plasma and whole blood; all other therapeutic measures are of secondary importance.

Once a clinical appraisal of the patient has been accomplished it is possible to decide within approximate limits the degree of shock which exists and plan replacement therapy accordingly. Study of Table I* indicates the approximate amount of replacement therapy that will be necessary to treat various degrees of shock. These figures are more or less empirical and based only upon individual clinical judgment -- not upon accurate measurement of the degree of oligemia.

The procedure in treatment of moderate and mild degrees of shock usually follows a rather uniform pattern. The patient is admitted; his blood pressure and pulse are recorded and a brief survey of the degree of shock is made. If there is no evidence of injury to the spinal cord and shock is not severe, the patient's clothing is removed while minimizing his exposure to cold. If possible, it is preferable to move the patient to another litter which has been properly dressed with clean, dry blankets. The patient remains in the recumbent position and is gently lifted while the new litter is placed beneath him. Having made the patient as comfortable as possible, the number and location of the wounds are noted and a physical examination performed in an attempt to decide the probable extent of the trauma. Once this has been accomplished, a large (18 gauge) needle is inserted in an arm vein and a sample of blood obtained for cross-matching; the administration of plasma is started immediately through this needle and is continued until matched blood is

* See page 124.

ready. During the infusion of plasma, wounds are checked for bleeding; the urine is examined and a Levin tube is passed. The presence or absence of blood in the gastric contents is noted on the shock record. Occlusion of sucking wounds of the chest with vaseline and gauze dressings must be done if it has not been done previously. If the degree of shock is mild or moderate, sufficient improvement in the clinical condition will roentgenographic studies to be carried out and the patient should be ready for surgery within 60 to 90 minutes, having received approximately 500 c.c. of plasma and 500 to 1000 c.c. of citrated blood. The administration of blood is continued as operation is begun and additional matched blood is held in reserve for use during surgery. Even in these cases of mild or moderate shock, the average patient will receive an additional 1000 c.c. during operation. Only by this means may preoperative therapy be supplemented and the unavoidable blood loss during surgery be corrected.

The routine infusion of plasma and cross-matching for transfusion offers several advantages in the care of patients even with no manifest shock or mild shock in forward hospitals for the following reasons:

1. The most effective means of shock therapy are utilized promptly to prevent the development of shock or, more importantly, to prevent the progression of mild into severe shock.

2. It constitutes a means of compensating therapeutically for the difficulty in accurately estimating the interplay to oligemia and peripheral vasoconstrictor activity. Thus, sudden collapse is largely prevented in this group of patients.

3. Early replacement therapy, by further stabilizing the circulation, increases the ability of the patient to withstand blood loss and anesthesia during operation.

4. The prompt institution of shock therapy allows greater flexibility in selecting from the preoperative ward those patients who are ready for surgery. This is of extreme importance during rush periods and allows the surgical teams to proceed with the task at hand so as to curtail the preoperative delay for all patients.

We are aware of the fact that many patients who exhibit only mild or moderately severe shock may improve considerably without the benefit of replacement therapy, simply when allowed to remain quiet. It is our preference, however, to provide some replacement therapy at first; if conditions are such that operation will be delayed, transfusion may be discontinued when it is judged to be sufficient. Often, under these conditions, the needle in the vein is kept open by the slow administration of saline or glucose and saline solutions.

Whereas the treatment of mild or moderate degrees of shock is usually not difficult, the successful treatment of severe or profound shock

is often extremely so.

All evidence indicates that the oligemia may be extreme when the blood pressure has fallen to excessively low levels; after a loss of 50% of the normal blood volume the average systolic blood pressure will usually be below 50 mm. (4). The patient in severe or profound shock will usually have an admission systolic blood pressure of 70 mm. or below, though occasionally it may be higher. Such patients require prompt and vigorous replacement therapy to provide a circulating blood volume which will prevent irreparable damage to body tissues and death. Furthermore, patients in severe shock frequently receive relatively large quantities of plasma prior to reaching the field hospital with a consequent further depression of the hematocrit. When the dilution effect of large volumes of plasma is added to the physiological response to hemorrhage, the hemacrit value has been observed to fall as low as 20 to 22 volumes percent. Herein lies the chief limiting factor in the use of plasma in the severely wounded, and whole blood is the agent of choice in the treatment of severe posthemorrhagic shock. If anemia is severe the effects of anemic anoxia may be appreciable even though the blood volume and cardiac output are not decreased. Study the effects of hemorrhage in the wounded has shown that hemoglobin loss is consistently greater than blood volume loss; the greatest deficiency is not in the plasma constituents but in hemoglobin (4).

If the patient exhibits severe shock on admission, a rapid search is made for continuing hemorrhage and blood (low-titer*, Group O) is started immediately (except in such an emergency all blood is cross-matched prior to its administration). A rapid flow must be maintained so that the patient will receive 500 c.c. of blood within the first 15 to 20 minutes (as much as 1000 c.c. of blood have been given in 15 minutes without deleterious effect). In the cases with most profound shock, it is advisable to start a second transfusion in the opposite arm or a saphenous vein using matched blood as soon as it becomes available. Cannulization of a vein should be performed without delay if constriction and collapse of the vessels precludes successful venipuncture. Inclosing an arm in a warm moist towel has proved to be of great assistance in accomplishing venipuncture even in severe shock.

Our experience indicates that patients survive only a very short time once the systolic pressure falls below 40 to 50 mm. of mercury. In other words, a stabilization of the circulation at such a low level rarely occurs; the pressure continues to fall until death results or spontaneous improvement occurs through cessation of bleeding and hemodolution.

* Iso-agglutinin titer 1:64 or below.

When excessively low blood pressures are observed the failure of the vasoconstrictor mechanism to compensate for reduced blood volume is often the result of severe or progressing hemorrhage and the preceding period of intense vasoconstriction and shock tends to be of shorter duration than when blood loss has been slower. Consequently, when shock is of relatively short duration the response to vigorous transfusion may be prompt in spite of the fact that the blood pressure has reached an excessively low level. Conversely, death may rapidly supervene in the absence of therapy. Richards (3) mentions the importance of transfusion in restoring the adequacy of the vasoconstrictor mechanism -- a rise in blood pressure may occur which is out of proportion to the volume of blood which is given initially.

Inspection of Table I ("The Problems of Shock Therapy in Abdominal Wounds", page 122) indicates that a patient in profound or severe shock will receive between 2000 and 2500 c.c. of blood or blood substitutes prior to surgery. Likewise, he will receive two to three times as much whole blood as plasma. We do not believe this represents overtreatment; the severe blood loss in battle casualties has been cited previously.

Through preoperative replacement therapy an attempt is made to prepare the patient adequately for operation; ordinarily this means that the circulatory dynamics should be restored as nearly as possible to normal. Often this cannot be accomplished through replacement therapy alone and within practical limits, sufficient therapy is provided to allow the patient to successfully withstand operation. The decision that a patient is adequately prepared for operation is a difficult one to make since it is impossible to evaluate clinically the interplay of such factors as oligemia and the vasoconstrictor mechanism. In this respect, clinical judgment is by far the best guide; one must not be led astray by normal blood pressure levels in the presence of tachycardia, thready pulse and clinical evidence of vasoconstriction. The intensity of vasoconstriction during the response to replacement therapy is not completely understood -- usually a rising blood pressure is associated with a fairly prompt increase in the peripheral blood flow; less frequently evidence of considerable reduction in blood flow to the periphery persists even when the blood pressure approaches normal levels.

From the practical standpoint, one must assume that the circulating blood volume has been adequately restored when evidences of peripheral vasoconstriction cease to exist and the blood pressure has approached normal levels. To accomplish this, blood and plasma are given in the amounts required (within certain time limitations to be discussed later). In respect to replacement therapy such a patient is deemed to be ready for surgery. It must be remembered that the patient who has partially recovered from shock is apt to be in a changing and delicate circulatory balance, and seemingly minor factors such as loss of body heat, further hemorrhage, anesthesia, etc., may result in a sudden fall in blood pressure.

Resuscitation and Preoperative Care of the Severely Wounded (The Management of Shock in Forward Areas, contd)

Therefore, it is wise, if in doubt as to the adequacy of therapy, to err in the direction of liberal replacement to provide additional stabilization of the circulation.

Two factors (aside from agonal shock) interfere greatly with the effectiveness of transfusion therapy in the management of shock. These factors are continuing hemorrhage and beginning virulent infection.

Practically all severely wounded patients continue to lose blood in varying amounts during the preoperative period. This is of greatest importance when the blood loss (not controlled by simple first aid measures) proceeds at a rate sufficient to render transfusion therapy ineffectual. Such blood loss may be from a single large vessel or, more commonly, from many smaller vessels which have been lacerated.

The control of the overwhelming infection remains as one of the greatest problems with which military surgeons are confronted. Those infections which have proved to be of greatest importance in immediately threatening life are: massive infection of the peritoneal and pleural cavities; anaerobic myositis and anaerobic cellulitis. Clinical experience indicates that the peripheral circulatory failure which is seen in the presence of severe infection is very often difficult to treat successfully by means of replacement therapy.

It is believed that a poor response to vigorous shock therapy (2000 to 2500 c.c. of plasma and blood given within one to two hours) is strongly indicative that significant hemorrhage is continuing or that fulminating infection is beginning. Unfortunately, these two condition often coexist. Since neither threat to life is amenable to replacement therapy alone, early surgery is indicated and every attempt is made, through intelligent therapy and triage, to limit the preoperative delay to two to three hours. All such patients constitute difficult problems during surgery and means must be available to supply relatively large quantities of blood during operation. In this respect an interesting trend has been noted as surgeons have become more familiar with the problems of war surgery. Many careful observers feel that the preoperative delay should be curtailed as much as possible (with concomitant vigorous replacement therapy) in abdominal wounds and believe that successful resuscitation can be carried out during surgery. This practice has several advantages, chief of which are earlier control of contamination and infection, and a reduction in the total amount of blood lost. However, it may not be possible to give sufficient plasma and blood within a short time (20 to 30 minutes) to prevent fatal collapse upon the induction of anesthesia, particularly when massive hemorrhage has occurred.

Resuscitation and Preoperative Care of the Severely Wounded (The Management of Shock in Forward Areas, contd)

In summarizing our views on the therapy of severe wound shoc, we believe that the capabilities of properly designed replacement therapy will be exhausted within two to three hours and that in no case should operation be wilfully delayed beyond this period.

Therapeutic Problems Peculiar to Certain Types of Wounds

Thoracic Wounds. In the control of associated chest wounds it is mandatory that cardiopulmonary physiology be returned as nearly as possible to normal. Fortunately, direct and successful means are available to accomplish this. They are: occlusion of sucking wound; the aspiration of blood and air from the pleural spaces; intercostal nerve block (procaine); endotracheal aspiration and the administration of oxygen. (See "Resuscitation in Thoracic Casualties", page 425) If the wound is not thoracoabdominal in type, autotransfusion has been routinely employed when thoracentesis results in the removal of a significant quantity of blood. The problem of shock therapy in the average thoracic wound has not proved to be difficult when such measures are utilized. In the management of chest wounds the volume of transfusion therapy is held to an effective minimum to prevent excessive bleeding into damaged pulmonary tissues or the development of pulmonary edema. Having been aware of these possible complications we have observed clinical pulmonary edema very infrequently during the preoperative period even in patients with apparent pulmonary blast injury. Most chest injuries require that the patient be placed on his side during operation and cannulization of a saphenous vein is helpful in insuring continuity of transfusion therapy during operation; the position of the patient may render transfusion unsatisfactory by the antecubital veins.

Extremity Wounds with Fractures. The relatively high incidence of pulmonary fat embolism in patients with severe trauma to bones has been noted. In addition to insuring adequate replacement therapy and reducing the blood loss by first aid measures, it appears that means of controlling fat embolization should be employed if possible. At the present time it appears that the only adjunct to surgery which may prove worthwhile is the application of an effective torniquet during the time that debridement and manipulation of injured extremities are being carried out.

Wounds of the Spinal Cord. In the presence of lesions of the spinal cord it should be remembered that a sustained rise of blood pressure may be difficult to attain even with the use of excessive quantities of blood and such a patient may be exposed to the dangers of massive group O blood transfusions unnecessarily. In general, the care of the patients with high spinal cord lesions is discouraging.

Figure 4: A Patient in the Shock Ward of a Field Hospital

Maxillofacial Wounds. The chief therapeutic problem in such wounds is the maintenance of an adequate airway. Suction equipment for clearing the oropharynx should be available at all times. Emergency tracheotomy may be required and means should always be at hand to accomplish this without delay.

The Use of Means Other Than Replacement Therapy in the Management of Shock

There are several important adjuncts to transfusion therapy in the treatment of shock. These are: placing the patient on a clean, dry, properly dressed litter to curtail loss of heat from the body; the control of pain by adjustment of splints and the judicious use of morphine; contolling blood loss as much as possible by pressure dressings and the application of effective tourniquets when necessary; gastric drainage by Levin tube; and last but not least, the avoidance of excessive moving or manipulation to insure as complete rest as possible. A patient always responds better if he is made comfortable.

Oxygen therapy (BLB mask or nasopharyngeal catheter) is useful in thoracic injuries as stated above, and is of great value in overcoming the anoxic anoxia of morphinism. Beecher (19) has emphasized the delayed absorption of subcutaneous morphine in severe shock and the intravenous route is employed in administering morphine (1/8 to 1/6 grain) to all such patients. Great care, however, should be used in giving any morphine in the presence of profound shock because the full absorption of previous doses may result in depression of respiration only after resuscitation has been in progress for quite some time. It has been the policy to administer oxygen in all cases of profound shock, and it is our impression that it is of value if used early and in high concentration. Often the ashen-grey cyanosis of profound shock will clear considerably with the administration of oxygen -- in other cases, clinical evidence of improvement may not follow oxygen therapy.

The external application of heat has been studiously avoided, particularly in the presence of the more severe degrees of shock. The loss of vasoconstriction and the increase of blood flow which follows the warming of an extremity can only result in a decrease in the volume of blood which is available to maintain the central circulation (3)(18). Furthermore, considerable evidence exists that tissues survive anoxia longer when the temperature is reduced and the skin and muscles are less sensitive to oxygen lack than the brain and other organs. However, chilling and loss of body heat must be avoided since it is poorly tolerated by the patient in shock.

At the present time it is generally agreed that elevation of the feet ("shock position") is a valuable adjunct in the treatment of shock. A

rather prompt rise in blood pressure and clinical improvement follows elevation of the foot of the litter in cases with mild shock. Richards (3) reports a similar finding and reports the significant observation that the pressure in the right auricle does not rise when the patient is placed in the shock position. He believes that the improvement is due to increased efficiency of the central circulation supplying the brain.

We believe elevation of the feet has its greatest usefulness in improving the circulation under conditions in which the venous system contains a relatively large quantity of blood; namely, (1) those cases with traumatic myelitis and (2) during the administration of general anesthesia. Several instances have come to our attention which substantiate the usefulness of the shock position in these conditions and we feel that it deserves emphasis as an adjunct to transfusion therapy in the control of shock during anesthesia. When the patient remains upon an unsupported litter during operation the head and upper thorax often lie considerably above the level of the remainder of the body due to the presence of arm boards and sagging of the litter. Elevation of the feet under such conditions has often resulted in a rise in the patient's blood pressure.

In the treatment of profound shock the shock position is routinely employed as an adjunct to rapid transfusion therapy. In these cases it may accomplish relatively little (3) and is never employed alone.

The determination as to whether or not replacement therapy has been adequate is difficult because of the many factors which are involved. A sudden fall in blood pressure with the induction of anesthesia is of practical importance in indicating that replacement therapy has been incomplete; death in the immediate postoperative period without sustained recovery from shock affords conclusive evidence that replacement and surgical therapy have failed to halt the inexorable effects of a lethal wound. Inadequate or unsuccessful shock therapy usually depends upon one or more of the following factors:

1. Failure to recognize and to treat adequately incipient shock.

2. Failure to analyze critically the clinical response to therapy with consequent inadequate replacement.

3. Transfusion at an ineffectual rate, particularly in relation to a failure to control external bleeding by effective first aid measures.

4. Poor triage and excessive delay or surgery in patients who respond poorly to replacement therapy because of progressive internal hemorrhage and beginning severe infection.

Resuscitation and Preoperative Care of the Severely Woundea (The Management of Shock in Forward Areas, contd)

5. Excessive delay in evacuation or in the institution of adequate therapy. Irreparable cellular damage due to the combined effects of prolonged and severe shock and beginning infection.

In evaluating the cause of death in the severely wounded a great many factors appear to be concerned. During the postoperative period, shock is a very frequent manifestation of impending death in such patients but it may be impossible to determine whether shock is the actual cause of death or simply indicative of a widespread disintegration of metabolic functions. For further discussion of irreparable renal damage which occurs following severe shock, see "Posttraumatic Renal Failure", page 758 Likewise, the section "The Problems of Shock Therapy in Abdominal Wounds", page 122, deals with the relation of the severity of shock to mortality rate.

It must always be remembered that early and adequate surgery is in itself a most important and final means of controlling shock by effectively stopping blood loss and limiting the ravages of infection through careful debridement and closure of wounds of the gastro-intestinal tract. It is obvious that preoperative care and surgery are mutually interdependent -- neither alone is sufficient and the two must be combined and correlated to the highest degree if the severely wounded patient is to survive.

SUMMARY

1. The pathogenesis of wound shock is discussed briefly in relation to the present concepts of the fundamental circulatory disturbances which follow injury.

2. Factors which have been observed to play a role in the causation of shock in wounded men are discussed.

3. A detailed account is given of the management of shock in the severely wounded.

4. Failures in shock therapy are considered briefly.

CONCLUSIONS

Battle casualties have received blood and blood substitutes on a large scale in order to restore the circulating blood volume and thus minimize the incidence and severity of shock during the accomplishment of initial surgery. The blood loss in such patients is apt to be considerable; often it may be extreme and in such instances vigorous replacement therapy is required. Through the use of blood and blood

substitutes, the scope of initial surgery has been widened to include many patients who have been resuscitated from severe or even profound shock. The surgical care of the less critically wounded, has by like means, been greatly facilitated.

Beginning fulminating infection and continuing hemorrhage have proven to be the most important factors in limiting the effectiveness of transfusion therapy. These factors, acting singly or together, are frequently responsible for prolonged or severe shock which proves fatal in spite of liberal replacement therapy.

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APPENDIX

ILLUSTRATIVE CASE RECORDS

<u>Case Number 1</u>

WIA by shell fragments; arrived in the Field Hospital one hour after injury. Blood pressure 0/0. Evisceration of 90% of the small bowel through a large defect in the right lower abdominal wall. Large amount of blood oozed from the abdominal wound. Patient was given 1250 c.c. of plasma and 2000 c.c of blood, but practically no response was observed. One and one-half hours after admission the patient was taken to surgery; B/P. 0/0. Bleeding was in progress from the mesenteric vessels and the inferior apigastric artery. There was massive contamination of the peritoneal cavity due to multiple lacerations of the bowel. Patient expired on the operating table.

Comment: This case indicates the overwhelming degree of trauma which had produced evisceration and the severe contamination of the peritoneal cavity. These facts plus the progressive hemorrhage were responsible for the severe shock which did not respond to liberal replacement therapy. The patient had a blood pressure which was too low to measure for more than one and one-half hours; the implications of this fact in relation to resuscitation therapy require no comment.

Case Number 2

P.O.W. Patient admitted with evisceration of small bowel, B.P. 0/0. The time of injury was not known. Perforating wound of the abdomen. Remained in shock ward for five hours during which time he received only 250 c.c. of plasma, 1000 c.c. of blood and 1000 c.c of 5% glucose in saline solution. At the beginning of surgery the blood pressure was 80/60. At operation there was severe contamination of the peritoneal cavity secondary to transection of the jejunum, and perforation of the splenic flexure of the colon. Bubbles of gas were noted in the "anterior abdominal wall". The patient expired on the operating table.

Comment: This case illustrated two important points. First, the transfusion therapy was given at an ineffectual rate. 1250 c.c. of blood or blood substitutes is not sufficient therapy in the presence of profound shock, particularly when it is spread over a period of five hours. This amount of therapy should have been given in a period of 60 to 80 minutes or less. Second, the preoperative delay was excessive in a patient who responded poorly to replacement therapy due to the presence of evisceration and massive peritoneal contamination in addition to probable anaerobic infection of the abdominal wall.

Case Number 3

Penetrating wound of the abdomen with evisceration of small bowel. Patient was seen two hours after injury at which time the blood pressure was 120/80; shock was mild in degree. During two and one-half hours in the shock ward the patient received 250 c.c. of plasma and 500 c.c. of blood. Prior to operation the blood pressure was 146/70. At operation no peritoneal contamination was present, nor was there excessive bleeding. During surgery the patient was given an additional 500 c.c of blood. Patient did well and was evacuated from the Field Hospital.

Comment: This case illustrates the fact that evisceration of bowel had existed for two hours without the development of an appreciable degree of shock. Obviously the extent of injury was much less than in the

first two cases. The good prognosis in the absence of peritoneal contamination is fairly characteristic of this group of cases in contrast to those in which peritoneal contamination exists. The lack of serious hemorrhage is likewise of extreme importance.

Case Number 4

Patient wounded in action at 1600 hours by shell fragment which penetrated the right hip. On arrival at the Field Hospital the blood pressure was 40/0. The patient was given 250 c.c. ob plasma and 1000 c.c. of blood. Surgery was started at 2000 hours; blood pressure 30/0. At operation the following diagnoses were made: fracture, compound, comminuted of the acetabulum, right, with severe destruction of the right ischium; multiple perforations of the small bowel and transection of the ileum; avulsion of the superior gluteal vessels, right ureter and sciatic nerve; perforation of the rectosigmoid colon. In addition, severe retroperitoneal anaerobic infection with gas formation was noted. The patient expired nine hours after operation.

Case Number 5

WIA at 0745 hours by shell fragments. On admission to the hospital the blood pressure was 0/0 and the patient was in profound shock. In spite of the administration of 250 c.c. of plasma and 1500 c.c. of blood the blood pressure remained at 0/0. The patient was apprehensive and restless and there was severe abdominal pain; crepitus was present in the abdominal wall about the wound of entrance and about the missile which lay in the subcutaneous tissue, and the presumptive diagnosis of anaerobic infection of the abdominal wall was made. At operation, started six and one-fourth hours after injury, there were found multiple perforations and transection of the ascending and transverse colon with tearing of the transverse mesocolon, multiple perforations of the jejunum, and avulsion of the lower third of the left kidney. The abdominal cavity was filled with foul-smelling dark fluid which contained bubbles of gas. The patient expired on the operating table at 1430 hours.

Comment: Both of these cases demonstrate the poor response to shock therapy in the presence of overwhelming infection as well as the rapidity with which anaerobic infection may become manifest in the presence of massive fecal contamination of the peritoneal cavity and retroperitoneal tissues.

Resuscitation and Preoperative Care of the Severely Wounded (Appendix, contd)

Case Number 6

P.O.W. Penetrating wound of the abdomen via the right buttock. Admission B.P. 0/0. During four hours of shock therapy the patient received 2500 c.c. of blood but the blood pressure was never measurable. At operation 4000 c.c. of blood were present in the peritoneal cavity and active bleeding was in progress from the right internal iliac vein and artery. The patient expired on the operating table.

Comment: The inability to attain effective transfusion therapy in the face of such progressing hemorrhage is obvious.

Case Number 7

Received shell fragment wounds of the left lateral chest at the level of the tenth rib at 1215 hours, 9 October 1944. Admitted at 1900 hours in profound shock with blotchy, grey cyanosis of the legs. Prior to operation received 1000 c.c. of blood with poor response. At 2130 hours the B.P. was 80/60, pulse 100, and operation was advised. Upon moving the patient to X-ray the blood pressure fell considerably. At operation (2155-2330 hours) a badly torn spleen was promptly removed and 2000 c.c. of blood were noted in the peritoneal cavity. On opening the lesser peritoneal sac the lacerated splenic artery was found to be actively bleeding. During the control of hemorrhage the blood pressure fell to 0/0 and 1500 c.c. of blood and 1250 c.c. of plasma were given during the remainder of the operation with a steady improvement in the condition of the patient; at the end of operation B.P. 92/50, P. 100. During the operation two perforations of the stomach were closed, the diaphragm was repaired and the sucking wound of the chest closed. The immediate postoperative period was stormy but the patient was sent to the rear in good condition and was ultimately evacuated to the Z. of I.

Comment: Another example of the need for early surgery in the presence of continuing internal hemorrhage. Replacement therapy could never have been completely successful in the control of shock until hemorrhage had been stopped.

Case Number 8

Injured by mine explosion at 1620 hours, 6 November 1944. During evacuation the patient received 1750 c.c. of plasma, 1/2 grain of morphine tartrate, and one c.c. of ephedrine sulfate. Arrived at the Field Hospital at 2300 hours at which time the B.P. was 152/30, P. 128. In spite of the level of the blood pressure the patient exhibited signs of severe shock with cold skin and a rapid pulse of poor quality. There

were multiple penetrating wounds of the right thigh, left upper chest, right forearm and left hand. A constricting circular bandage was present about the right thigh and the right leg was cyanotic and cold. A transfusion of 500 c.c. of blood was given and operation begun. The lacerated right femoral vein was ligated and multiple wounds were debrided. Those of the left chest were found to be superficial. During operation the blood pressure fell to 50-60/0 and 1500 c.c. of blood were given. At the end of the operation the B.P. was 90-95 mm. systolic. Following operation the condition of the patient was fairly good in spite of the fact that he showed a persistent tachycardia (P. 150) and B.P. 80/60. On the day following operation the patient was given a transfusion of 1000 c.c. of citrated blood without reaction. Patient expired approximately 24 hours after operation.

Autopsy findings: Gross: Fracture of the fifth rib in the left anterior axillary line; moderately severe contusion of the peripheral portion of the upper lobe of the lung. Congestion and edema of the lungs, particularly in the dependent portions; the bronchi and trachea contained a considerable quantity of frothy serous fluid. There was no evidence of contusion of the abdominal wall or penetration of a missile into the peritoneal cavity. Throughout the extent of the small bowel there were numerous subserosal ecchymoses which become progressively more numerous as the terminanl ileum was examined. In the terminal portion (35-40 cm.) of the ileum there were extensive subserosal hemorrhage and edema, and the wall of the bowell appeared to be undergoing necrosis, being dark in color, considerably distended, and covered by thin strands of fibrinopurulent exudate. However, no perforations were present. The lumen of the bowel contained a large quantity of hemorrhagic, necrotic mucosal slough. The circulation through the smaller vessels appeared to have been severely compromised but there was no evidence of thrombosis of the larger mesenteric vessels.

Microscopic examination confirmed the presence of necrosis of the bowel wall but there was no evidence of local thrombosis of the smaller vessels though all were engorged with blood. Sections of the lung showed hyperemia of the alveolar septa, scattered intra-alveolar hemorrhage with patchy atelectasis, and emphysema. A small number of fat emboli were seen in the capillaries of the alveolar septa.

Comment: This case illustrates the damage which blast injury may produce in air containing viscera. The high admission blood pressure is of interest in relation to the previous administration of a large quantity of plasma and ephedrine. In spite of the level of the blood pressure, the patient exhibited well marked evidence of shock from the clinical standpoint.

Case Number 9

Incurred shell fragment wounds of left chest and right thigh at 1400 hours, 30 March. Arrived at the Field Hospital at 1820 hours after having received 1250 c.c. of plasma. Blood pressure at this time 98/40; slight cyanosis was observed and respirations were labored. Multiple rib fractures noted along missile tract from shoulder region to exit wound at level of the 10th rib. Thoracentesis, left, resulted in removal of 1500 c.c. of blood and a small amount of air. Prior to operation the patient received 500 c.c. of plasma and 1700 c.c. of citrated blood. At 2135 hours, blood pressure 130/70 mm.

Operation: (Anesthesia started 2135; ended 2330). Debridement and closure of chest defect (4 x 8 cm). Fractures of second to fifth and tenth and eleventh ribs and extreme damage to subcutaneous tissues were noted. Extensive gutter wound at left upper and lower lobes. Anterior and posterior catheter-water seal drainage of left pleura was provided and the left chest firmly strapped with adhesive. Debridement of extensive perforating wound of right thigh and buttocks, (no fracture present). Blood pressure at end of operation was 130/70 mm.

Postoperative Course: At 0530 hours, 31 March, the blood pressure had fallen to 90/40 mm.; pulse 120, of good quality. Respirations shallow. Breath sounds were diminished or absent over the left chest but were normal on the right. Rales were not noted. Anterior drain functioning properly. Progressive slowing of respirations and death occurred at 0635 hours, in spite of continuous oxygen therapy.

Postmortem Findings: Gross: Extreme traumatic infarction of posterior aspect of both lobes of the left lung. Severe congestion and edema of involved portions of left lung and the whole of the right lung. Remainder of gross examination was essentially negative.

Microscopic: Pulmonary, myocardial and renal fat embolism, severe.

Comment; This case illustrates an unusual degree of fat embolism. The source of the fat appears to have been the fractured ribs and traumatized adipose tissue of the left chest wall. The man was wounded in a tank, and blast injury may have been partly responsible for the severe embolism. Cerebral fat embolism was no doubt present but the brain was not examined.

THE OPERATING ROOM

AND THE

OPERATION

THE OPERATING ROOM AND THE OPERATION

The Field Hospital operating rooms have usually been in tents, although building have been utilized on occasion. Either single or double (side-to-side) ward tents were used. Each had its advantages and its disadvantages. The double tent was more spacious and convenient and generally the more suitable. However collections of snow or rain on the roof with resultant leakage were drawbacks to this type of tent in the winter months. The single tent was more stable in high winds and less inclined to leak, but here the operating quarters were cramped and the erection of cubicles for surgery was not possible.

In summer, a tent hospital in a field soon became extremely dusty, and passing vehicles on unpaved roads even 100 yards away raised dust clouds which billowed across the area and into the operating tent. Personnel walking through the surgical theater raised more dust from the ground. Water for sprinkling was seldom available, and when it was, evaporation was usually so rapid as to nullify the effort.

It has been impossible to control completely flies and insects. Fitted wire screens and doors could not be carried because of limited motor transport. The tents were screened with cheesecloth and discarded mosquito netting. The benefit from these measures was only partial, and was largely offset by the constant passage of personnel into and from the tent, and by the wind.

To those trained in the aseptic ritual of the modern surgical amphitheater, conditions in tent operating rooms were at first sight appalling. Temperatures varied from near freezing in winter to almost intolerable heat in summer. The floor was often either thick mud or the powdery dust of desiccated, richly manured earth. Flies were a plague in summer and in winter the roof often leaked onto the sterile field. The meager space about the operating table was always crowded. The passage of personnel on necessary errands taking them through the operating tent has been nearly continual in times of heavy casualties.

One would expect in these conditions epidemics of wound sepsis, anaerobic infection, and cross-infection, and would think it impossible that streptococcal and other wound infections should not be prevalent. Yet in our experience wound infections other than those directly attributable to contamination from a soiled peritoneal cavity have been unusual. Clinical streptococcal infections have been of great rarity. There has been no instance of apparent contamination from case to case. No case of so-called "surgical scarlet" or "wound erysipelas" has been encountered. Anaerobic infections have been observed primarily in winter, when they were attributed to mud carried in by missiles;

clostridial seeding of wounds by contaminated dust in the summer months does not appear to have occurred.

In spite of the crudeness of facilities, the surgeons of this organization have always observed at the operating table the rigid procedures of aseptic technique. Wide, painstaking skin preparation with soap and water and thorough shaving have been done. Ample sterile drapes have been used except in situations where the linen supply was critical. Supervision of the operating room conduct of enlisted personnel has been strict. Masks and caps have been provided for all passing through the operating room and their use has been required. Instruments, gloves, and when possible, gowns have been changed whenever indicated by contamination, either accidental or by a soiled wound.

We believe that it is of the utmost importance for the forward surgeon never to compromise his observance of the aseptic technique regardless of working conditions. We feel that observance of operating room surgical discipline more than any other factor has made possible the low incidence of exogenous wound infections which we have observed. The sulfonamides and penicillin have doubtless aided in the prevention of sepsis, but we believe their role to have been secondary in importance to the surgeons' observation of the rules of the operating theater.

TIME ELEMENT

Since approximately 50% of all cases had associated wounds, it will be appreciated that the need for surgery other than that to the abdomen has been great. Debridement of multiple extremity wounds can be difficult and time-consuming. Some feel that additional operating time so spent may be hazardous to the patient, but we believe that this is rare indeed. The usual practice has been to perform all indicated surgery at the original operation, except in a very few cases where it appeared definitely unwise to continue debridements to completion. In the usual case, the danger to the patient of incompletely treated peripheral wounds was as great as that of an additional 30 or 45 minutes on the operating table. The vast majority of battle casualties have been found to tolerate well operations of great extent and duration. Secondary operations in the early postoperative period are undesirable in the abdominal case, and such procedures are necessary if the original operation has not been complete.

The need for rapid, straightforward, purposeful surgery, and for reduction to a minimum of time lost between cases must be emphasized. The saving of time is of far greater importance to the patient await-

The Operating Room and the Operation (Time Element, cont'd).

ing his turn for surgery than it is to the case on the operating table. In times of great activity and heavy casualties, the patients may be delayed several hours in the preoperative ward because all surgeons are occupied. It is for the man who is awaiting surgery, and whose time lag is inevitably increasing, that the surgeon must use time with maximum efficiency.

Figure 5: Tent Operating Room of a Field Hospital.

GENERAL

CONSIDERATIONS OF ANESTHESIA

IN

WAR CASUALTIES

GENERAL CONSIDERATIONS OF ANESTHESIA IN WAR CASUALTIES

INTRODUCTION

An Auxiliary Surgical Group is composed of officers, nurses and enlisted men, the latter being trained surgical technicians. The personnel is divided into teams, each of which is composed of a surgeon, assistant surgeon, anesthetist, nurse and two enlisted men. Since each team is to function independently, it is supposed to have its own transportation and its own surgical equipment. The anesthetist, for example, carries an anesthesia kit containing drugs, syringes, needles, Yankauer masks, endotracheal set, and blood pressure apparatus. In addition, he possesses a machine to administer closed anesthesia under positive pressure.

An important part of the treatment of battle casualties is practical and efficient anesthesia, and it should be administered by persons especially trained in this specialty. Naturally, there are wounds involving every organ of the body, singly or in combination with other injuries, and therefore the anesthesia may vary in type or in method. Also, there is greater choice of agents in the less seriously wounded soldier, and in the more rearward hospitals, inasmuch as these patients have a more stable circulatory balance.

Anesthetists are associated with teams specially qualified in various branches of surgery. These include not only general surgery, but also orthopedics, neurosurgery, thoracic surgery and maxillofacial surgery.

The locus operandi of an Auxiliary Surgical team is ideally in a forward hospital unit, preferably a Field Hospital platoon, where the earliest definitive treatment may be offered to the patients. Naturally this entails considerable disadvantages, not only in the working conditions, but also in the manner of living. For that reason, the personnel of an Auxiliary Surgical Group should be of a younger age group as a whole than that found in the usual hospital. Coincidentally, their general physical condition is superior to that of other medical personnel who do not suffer the rigorous life in the field to which members of the Auxiliary Surgical Group are exposed.

For the most part, the anesthetists in the Group are particularly well qualified, some being certified specialists, and others having experience in anesthesia either by virtue of special army training or private civilian practice. It is true that a few officers were appointed arbitrarily as anesthetists, and functioned as such, though their formal training in anesthesia was meager. No one can deny that they performed very creditably, and the more so as time went on. There were, likewise,

several nurse anesthetists in the Group, most of whom had had some training in anesthesia prior to their induction into the Army Nurse Corps, and were particularly familiar with inhalation anesthesia. Most of the surgeons who used these nurse anesthetists were entirely satisfied, although in occasional instances this arrangement added a natural burden to the surgeon, already concerned and occupied with the surgical aspects of the case. It would be desirable if a method of training anesthetists, male and female, could be evolved for the type of cases encountered in forward installations, with stress on endotracheal anesthesia and recognition and treatment of shock.

The Group, during its work in the Mediterranean Theater, took part in every amphibious operation, and consequently worked in every conceivable medical installation from Clearing Stations to General Hospitals, both American and British. Until the Field Hospitals were set up and functioning, the teams worked in Evacuation Hospitals and Station Hospitals for the most part. Working in Clearing Stations and medical battalions was never satisfactory, due to the obvious lack of facilities, equipment and personnel. It developed that the Field Hospital platoon was an admirable vehicle for the surgical teams, supplying the personnel and equipment which by necessity were not part of the Auxiliary Surgical Group. As a consequence, the preponderance of nontransportable cases in the Fifth and Seventh Armies during 1944-45 were operated upon in the Field Hospitals by the 2nd Auxiliary Surgical Group and attached teams.

Many of the difficulties and disadvantages of working in the forward areas have been eliminated as a result of experience. For example, the teams making the amphibious invasions of Anzio (Italy) and Southern France, were attached to Field Hospital platoons, which in turn brought ashore the teams' equipment allowing for speedy functioning. At Salerno, on the other hand, a few months previously, the teams, some of which were assigned to Clearing Stations, did not have their equipment on the boats with them. This all important materiel was not disembarked until D plus 2. Other factors militating against the best treatment of the patient, although later rectified in most instances, included lack of adequate tent flooring, poor heating arrangements for the tents in winter, insufficient blood for transfusions, absence of gas machines and other supplies, and too close proximity to our artillery for the patients' comfort.

Yet, in spite of the relatively minor discomforts, the privilege of working in such a medical installation far outweighed these temporary disadvantages. Here, as far as the anesthetist was concerned, each case offered problems seldom, if ever, encountered in civilian work. Further, the importance of good anesthesia was never more fully appreciated or necessary than in these severely wounded cases at the Field Hospital. This is the place where the anesthetist's skill, judgment and intelligence are constantly on display in the show case of combat zone surgery. From

this type of anesthesia a rich and satisfying experience may be obtained by the conscientious anesthetist. The manner in which the men of this Group met the challenge of these difficult cases supports the plea for more men trained in the practice of modern anesthesia.

ROLE OF THE ANESTHETIST

The integrity of each team rests on the interdependence of its members, and particularly the relationship between surgeon and anesthetist. The anesthetist should be able, by virtue of his general medical background and appreciation of surgical conditions, to relieve the surgeon of a certain amount of responsibility. This is especially true in his preoperative evaluation of the patient, assistance in the shock ward, knowledge of shock therapy, and performance of postoperative procedures on the ward.

In civilian or peace-time army anesthesia, the anesthetist is seldom concerned with the same responsibilities as in combat casualties. At a Field Hospital on the other hand, in addition to giving the anesthetic, he must learn to perform procedures with which he may not have been familiar up to that time. His previous training, his adaptability to this type of work, and his ingenuity are truly tested under these trying circumstances.

Occasionally, as must be expected among any large group of medical officers, there was someone who failed to adapt himself harmoniously to the position of being the anesthetist on a surgical team. This is not particularly strange inasmuch as these individuals perhaps had had some formal training in other fields of medicine, or expected to receive such training while working in the army. Since this was not practicable in this organization in all instances, and since there was an already existent dearth of anesthetists, these men were summarily designated as such. Most of those who were not at their ease in this position were later assigned to more suitable duties in this or another unit. The remainder were able to adjust themselves quite satisfactorily to the work in anesthesia.

It has been stated that the reason for the assignation of the inexperienced personnel to anesthesia was due to the difficulty of obtaining more adequately trained men. Every effort should be directed toward obtaining as many as possible of the best qualified anesthetists for the work in the forward hospitals. Certainly if the Field Hospital is to care for priority surgical cases, as was its function here, then the patients should enjoy the ministrations of priority anesthetists.

DUTIES OF THE ANESTHETIST

In addition to his usual facility in administering the various agents, the anesthetist in the Field Hospital must perform other special tasks in and out of the operating room for the care of the patient. Especially will his presence be appreciated in the preoperative shock ward, where he may profitably serve as a consultant or actually carry out some of the supportive therapy. Not always are the shock wards over-staffed, and particularly is this true during the busier periods. Another indisputable fact is that not all shock wards function at the same level of efficiency, and it is then that the anesthetist can materially assist in the patients' preparation and evaluation. The latter, we believe, to be of the greatest importance to the patients' welfare. A proper estimation of the condition of the wounded soldier to withstand surgery entails many factors, such as his nutrition, the season and degree of exposure, location and severity of the wound, possible blast injury, blood loss, replacement therapy en route, blood pressure and pulse with notation of their behavior since admission, premedication and contemplated surgery, to name the more important considerations. The picture the patient presents at this stage will depend upon the importance attached to these factors in the individual case by the experienced or inexperienced anesthetist. This subject will be further discussed under the section on general care of the patient.

The anesthetist is also in a position to assist in the preoperative care of the patient by his knowledge of local anesthesia. Therapeutic nerve blocking is a special feature in the treatment of certain wounds. Intercostal, paravertebral, and epidural blocks have an important place in the therapy of chest wounds. It would be of particular benefit to the anesthetist to be acquainted with these and other common procedures employing local anesthesia, not only for his war work but also for the practice of anesthesia in general.

Premedication, with special reference to the use of morphine, also concerns the anesthetist and his preoperative evaluation of the patient, but will be taken up below under the heading of "Premedication" (page 61).

Preparing the patient for surgery (shaving, washing, etc.) should be done as much as possible prior to the beginning of induction. This may be of extreme importance in reducing the total anesthesia time in badly wounded patients.

Dubing the operation, the anesthetist should be in complete command of the patient's condition. With closed endotracheal anesthesia using the CO_2 absorption method, he is able to maintain control of the respirations. He supervises the fluid therapy for the support of the blood

pressure and directs general antishock measures. In case of any untoward condition developing he so advises the surgeon, who then can modify or perhaps even stop his operating. At all times he must keep the airway patent.

Postoperatively he should be able to bronchoscope the patient if necessary, and this will be advisable in many instances, especially in thoracic wounds. A general appraisal of the patient's condition at the conclusion of the operation is of distinct value in determining the immediate postoperative therapy.

The responsibility of the anesthetist to the patient does not cease with the completion of the operation. In the immediate postoperative period he is concerned with the maintenance of a patent airway, antishock therapy, and general supportive measures while the patient is emerging from his anesthetic state. In most instances this cannot be personally supervised by the anesthetist himself, but must be handled according to his directions. Training the ward personnel in such procedures as tracheal aspiration with a soft rubber catheter is of inestimable value, particularly in cases with blast conditions or whenever there is an unusual amount of mucous or blood in the bronchial tree.

After the patient has recovered consciousness there are other features of his treatment which may be considered within the domain of the anesthetist. Of special importance is his ability to perform lumbar sympathetic blocks for vascular injuries in the extremities. Again, he may be called upon to perform diagnostic spinal puncture. In cases with painful incisions, it may be necessary to do intercostal, paravertebral-intercostal, or epidural blocks in order that the patient may cough efficiently, and thus increase his pulmonary seration. Occasionally, it is necessary for the anesthetist to bronchoscope a patient under local anesthesia for congestive or atelectatic conditions involving the lungs.

From the foregoing, it is obvious that the anesthetist should accompany the surgeons on their ward rounds in order to assist in the diagnosis or treatment of the postoperative patient. In this way, the anesthetist will not only broaden his perspective on anesthesia, but will assist in increasing the efficiency of his surgical team.

APPARATUS

In the early phases of the Mediterranean campaign, shortages of anesthesia equipment and other supplies were very definite hindrances to the administration of proper anesthesia and proper supportive treatment of the patient while under anesthesia. The basic items of anesthesia were supplied: agents, airways, Yankauer masks, laryngoscopes,

endotracheal tubes, syringes and needles, sphygmomanometer and stethoscope. With these agents and equipment pentothal could be given intravenously, ether administered by open drop, and spinal, local and regional procedures carried out.

Apparatus for closed-positive pressure-oxygen anesthesia was available in Evacuation and General Hospitals. Work done forward of these installations was without benefit of this method. Some efforts were made toward improvising equipment of this nature but none were successful enough to be widely adopted. Oxygen could be secured, but reducing valves were practically nonexistent. Reducing valves used in oxy-acetylene welding were sometimes obtained from engineer units when they could be spared. Plasma was plentifully supplied but blood supply was the concern of the individuals caring for the patient. Personnel of the unit where patients were being cared for, or other nearby units, were used as donors. Technicians and equipment for cross-matching blood were more often than not unavailable. Blood was given frequently without testing for compatibility or with no more than a gross test for agglutination. Illustrative of supply shortages that occurred was the experience of teams in a landing with a Clearing Station. The shortages listed are only those noted by the anesthetists as hindering their work:

1. No laboratory technician to procure and choose suitable donors.
2. No microscope, test tubes or glass slides.
3. No equipment, sterile or unsterile, for taking or administering blood, other than needles, syringes and sterile plasma tubing.
4. No Levin tubes or stomach tubes to empty stomachs.
5. No intravenous preparations of saline or glucose.
6. No means of giving a closed anesthetic.
7. No facilities for oxygen therapy.

Early in the Italian campaign, equipment and supplies became more plentiful. Platoons of Field Hospitals were each allotted one anesthetic machine. This was inadequate, however, as frequently two or three severe injuries were being operated upon at the same time. Major thoracotomies and thoraco-abdominal cases had priority on the single machine. In Evacuation Hospitals blood banks were set up. In Field Hospitals blood banks were not feasible at the time because the platoons were not authorized refrigeration. However, vacuum bottles with citrate became available, which was of great importance to the satisfactory and rapid collection of blood. Shock teams came into wide use and relieved the personnel of the surgical teams of the responsibility of having to draw blood at frequent intervals as needed by the individual patients. Oxygen equipment was available in limited quantities at this time. By improvising multiple oxygen outlets and connecting sections of plasma tubing together, oxygen could be piped to several patients from a single tank.

In March 1944, issue was started of the Beecher portable anesthetic machine (WD Item No. 9N01600) to platoons of Field Hospitals and shortly afterwards to many of the surgical teams. Thus each platoon had sufficient equipment for several closed anesthetics to be given simultaneously. By this time, the blood bank was functioning adequately.

After this time supplies were never a serious problem except in occasional instances where teams were required to work in clearing stations or medical battalions or in the first day or two of an amphibious landing.

Three types of anesthetic machines were in general use: Heidbrink, McKesson and Beecher portable model. The portable Heidbrink and McKesson machines are familiar to all anesthetists. The Beecher model was designed particularly for military use in the Pacific Theater to provide a compact light weight machine with which a closed positive-pressure ether anesthesia could be given using oxygen for a tank, or outside air provided by foot bellows. CO_2 absorption was to and fro in type. Induction could not be carried out with the machine. This was accomplished using ether or ethyl chloride open drop, or pentothal. Obviously an apparatus this size and weight could hardly have the full performance of the larger machines, yet many anesthetists reported satisfactory results using it in all types of cases.

PREMEDICATION

Premedication was, in most cases, simply the administration of 1/100 or 1/150 gr. of atropine. This was true for the reason that by the time the patient had reached a hospital installation he had ordinarily received an adequate or more than adequate dosage of morphine. Dosage totals of 1½ gr. of morphine were repeatedly noted, given over periods of time no longer than four to six hours. Some factors which favored overdosage are as follows: (1) Poor absorption of the drug due to impared circulation and/or exposure to cold with chilling of the body surface; the patient had no effect from the morphine already received and more was given along the chain of evacuation because the patient complained of pain. (2) The standard army morphine preparation for combat use is the ½ gr. syrette of morphine tartrate, which amount, if not too large for an initial dose, is certainly too large for additional doses. (3) Failure of morphine administration to be recorded on Emergency Medical Tags with subsequent needless repetition of dosage. (4) Inadequate education of those entrusted with morphine administration concerning the hazards of delayed absorption of accumulated doses.

Shortly after admission to a warm shock tent and improvement of circulation by restorative therapy, this hidden morphine came to light in the form of varying degrees of morphinism. In abdominal wounds with

mounting infection and cases of continuing hemorrhage, anesthesia and surgery could not be delayed for the reason of morphine depression. Aided or controlled respiration with a closed system was used to carry these patients through anesthesia. The difficulty of morphine overdosage might be corrected to a great extent by: (1) reducing the amount of morphine in a syrette from $\frac{1}{2}$ to $\frac{1}{4}$ gr; (2) limiting doses for each patient to two syrettes, over a period of six to eight hours, with reasonable exceptions or under the direct supervision of a medical officer; (3) urging that records be kept as accurately as possible (the difficulty of this under combat conditions is recognized); (4) administration of all morphine intra-muscularly, rather than subcutaneously by company aid men, at battalion aid stations, collecting stations, and clearing stations. The intramuscular route is not as sure as the intravenous route, but the latter method poses obvious technical difficulties which make its general use forward of hospital installations not feasible.

Additional morphine administered by us to these patients was done so only after examining the patient for signs of morphinism, checking the Emergency Medical Tag for time and amount of morphine given, and where accuracy was doubtful, the patient was questioned. The course of events both preadmission and postadmission also affected this decision. Suffice it to say that additional morphine was given meagerly and cautiously, and not at all if there were any doubts as to its need. Intravenous (into infusion tubing) was the logical and most commonly used route, in consideration of the unstable circulatory balance of these patients. This was given in combination with the atropine 10 to 15 minutes before anesthesia was expected to begin. Scopolamine was not in general use because of its central depressant action.

COMPLICATIONS

Generally speaking, the complications arising out of wartime anesthesia are the same as those met in civilian practice, due allowance being made for the incidence factor in the soldier age group. On the other hand, it must be kept in mind that the wounded patient often requires much more extensive surgery than the civilian patient, as well as suffering varying degrees of exposure, infection and shock, all contributing to anesthetic complications.

Moreover, the anesthesia is administered by personnel of variable training and experience. By the proper selection of cases and agents, and careful attention to dosage, the incidence of anesthetic complications can be appreciably lowered. It is probably a truism that the incidence of complications is in inverse ratio to the experience and knowledge of the anesthetist, and this is specially applicable in war anesthesia.

A full discussion of this topic is covered in any of the standard textbooks on the subject of anesthesia. The complications arising out of 3154 anesthetics in abdominal and thoraco-abdominal battle casualties is taken up under the section on (pp 182 : Anesthesia in 3154 Abdominal and Thoraco-abdominal Battle Casualties).

BLAST INJURIES

Any discussion of blast injuries must be qualified by stating that the statistical data recorded is quite incomplete as to the actual number of cases that had associated blast injury. The following discussion is based chiefly on the combined clinical impressions of our Group. Very few cases come to the operating table with the definite diagnosis of blast or as a predetermined major complication to wounds due to high explosive fragments.

The usual cause of blast injury is the detonation of a large charge of explosive in close proximity to the body, or as a result of direct trauma. This problem has been fully discussed by Martin and Schwab (Anesthesiology, March 1945). They considered both air blast and hydraulic abdominal concussion. (See section on Thoracic Injuries, page 411 .)

The treatment of these cases is quite difficult. The use of fluids is always a perplexing problem. The very slow administration of whole blood or plasma is the only variation in treatment from the usual care of casualties. Frequently the fluids must be stopped due to increase in pulmonary exudation. Oxygen per nasal catheter or B.L.B. mask, i.e., in high concentrations, is necessary because of the poor respiratory exchange and also in the treatment of the pulmonary edema. Morphine is used as indicated for pain and apprehension. Slight Fowler's position for comfort and efficient pulmonary ventilation is important.

The anesthetic management of severe blast cases is more difficult than that of other casualties, in that induction with inhalation anesthesia may be impared due to reduced alveolar exchange. Great care is exercised to carry the patient in as light a plane of anesthesia as is possible and to institute prompt treatment of any complications as they occur. A few severe cases developed marked pulmonary edema shortly after induction. Almost constant tracheal suction was necessary and smooth anesthesia was very difficult to maintain. Occasionally, it was difficult to provide satisfactory oxygenation for the patient. Under these circumstances it was the same type of treatment given any other case that became "wet". Postoperative bronchoscopy, repeated tracheal aspiration and oxygen under pressure were provided as necessary.

General Considerations of Anesthesia in War Casualties (Blast Injuries, contd)

Not all cases of blast were as severe as described and many times the anesthetist was not aware of the blast injury until the chest was opened and the petechiae or hematoma of the lung were demonstrated by the surgeon. For these patients, the anesthesia was no different than in any other case. All those who became "wet" were not blast casualties, but the greater percentage of pulmonary injuries were complicated by blast. Those patients who went on to recovery were treated as described under postoperative care, with fluid balance and a clear pulmonary tree being the chief concern throughout the treatment.

SUMMARY AND CONCLUSIONS

1. Anesthetists working in forward hospitals should be well trained, preferably of a young age group, and of good physical stamina. The advantages and disadvantages of working in combat installations are discussed.

2. Priority surgery demands the the anesthesia be administered by the best available anesthetists.

3. The duties of the anesthetist preoperatively, operatively, and postoperatively are noted.

4. The apparatus available to the anesthetists of the 2nd Auxiliary Surgical Group, both early and late in the war, are discussed.

5. Premedication, with special attention to morphine, and its dangers in war use, is commented upon. Methods for preventing the overdosage with morphine are listed.

6. Anesthetic complications in war anesthesia simulate those in civilian practice, allowance being made for the age group involved, and the severity of combat wounds.

7. Blast injuries in the war casualty are discussed from the anesthetist's standpoint of treatment and management on the table.

POSTOPERATIVE CARE
OF THE
SERIOUSLY WOUNDED

POSTOPERATIVE CARE OF THE SERIOUSLY WOUNDED; PREVENTION AND TREATMENT OF COMPLICATIONS

The necessity of constant attention to detail in the postoperative care of patients with serious war wounds cannot be overemphasized. If any appreciable reduction in the mortality and morbidity rates of this type of case is to be obtained, it must come from even greater diligence in combating shock and by the more successful prevention and treatment of the numerous complications which arise postoperatively. The nature and degree of the problem is illustrated by a tabulation of the principal causes of death in several large groups of seriously wounded or injured patients operated upon in forward hospitals of the Mediterranean and European Theaters in 1943, 1944 and 1945.

TABLE I

Causes of Death in the Seriously Wounded

Causes	Abdominal Wounds	Thoraco-Abd Wounds	Thoracic Wounds	Extremity Wounds *
Persistent shock	51%	52.6%	8.6%	44.6%
Intrathoracic complications	15%	21.0%	58.7%	17.5%
Abdominal complications	20%	10.4%	(2 cases) 1.7%	0.0%
Other complications	11%	11.0%	17.2%	36.5%
Not recorded	3%	5.0%	13.8%	1.4%
Total cases studied	2251	903	1364	2378
Total deaths	509	247	135	74
Mortality rate	22.8%	27.4%	9.9%	3.1%

* Includes amputations and fractures of long bones but not uncomplicated vascular injuries.

The data in this table apply only to the periods of treatment in the forward hospitals. "Persistent shock" was the most commonly recorded cause of death except for the group of thoracic injuries, and was included in the list though not a complication per se (see "Shock Syndrome" page 108). Fatal intrathoracic complications had by far their highest percentage (58.7%) in thoracic wounds. The rate for thoraco-abdominal wounds (21%) was not much higher than that for abdominal wounds (15%).

The latter figure was boosted somewhat by a higher percentage of pulmonary embolism in the abdominal wounds. Most of the fatal abdominal complications consisted of peritonitis, either general or local. A substantial portion of the "other complications" in each wound category was represented by the anuric cases. This highly fatal complication is discussed thoroughly in the section on "Posttraumatic Renal Failure" (page 758). Anaerobic infections formed the second most numerous group of cases under "other complications". Nonfatal complications, though generally similar in type and relative incidence to the fatal ones, could not be tabulated as accurately. This may have been due to the fact that these patients were followed only during their stay in the forward hospitals and that the records were incomplete in some cases (see section on "Postoperative Complications in Abdominal Wounds", page 203).

Details of postoperative care varied with the individual surgeons of the Group, but the underlying principles were essentially the same. They form the basis for part of the discussion in this paper. Special variations in postoperative management appropriate to wounds of the nervous system, to maxillofacial wounds, compound fractures, amputations, peripheral vascular injuries and genito-urinary injuries are detailed in the sections on those subjects. Most of these special cases, however, can be evacuated rearward far earlier than abdominal or thoracic cases and so present shorter treatment problems and fewer complications in the forward hospitals.

Fluid Balance

Every effort was made to keep the patient in a normal state of hydration, and to this end a majority of the surgeons utilized the following general routine. Fluid intake was usually maintained at 2000 to 3000 c.c. daily, unless there was a reason to increase or decrease the ammount because of complicating factors. When fluids were given parenterally, they were administered preferably by a drip mechanism which made it possible to accurately regulate the rate of flow. Fluids were spaced throughout the day and night. One or more liters of the total fluids given was normal saline, either alone or mixed with glucose. If the excretory function of the kidney was impaired, the administration of normal saline solution usually was restricted to not more than one liter per day. The remainder of the fluids consisted of five or ten percent glucose in distilled water and variable amounts of blood and plasma to meet the total fluid requirement. The danger of "drowning" patients suffering from anuria with too much water and saline intravenously should be emphasized. Patients who were losing excessive amounts of fluid by vaporization, vomiting, gastric suction, diarrhea or fistulae, received an additional ammount of saline solution to replace this loss. A daily output of 1000 c.c. of urine with a good specific gravity was a prime objective and served also as a useful clinical rule in determining the required fluid intake.

Thoracic casualties presented a special problem in intravenous fluid administration. Clinically patients did better if kept mildly dehydrated. Saline solutions also were given only to replace that lost by gastric suction and by other routes. It has been observed that traumatized lung tissue is particularly prone to become edematous after the administration of intravenous fluid.

The oral administration of fluids, although preferred, was contraindicated in the abdominal cases for varying periods because of the frequency of wounds of the intestinal tract and complicating peritonitis or paralytic ileus. Parenteral fluids were administered by vein almost always and infrequently by the subcutaneous route. Rectal administration was rarely utilized because of the uncertainty of the amounts that would be absorbed. The sternal route did not prove sufficiently satisfactory to be used widely.

ANALGESIA AND SEDATION

Postoperative analgesia and sedation have been handled somewhat differently than in major operative cases in civilian practice. Several points in regard to the routine use of morphine in the seriously wounded or injured bear emphasis. As a result of shock, relatively deep and prolonged ether anesthesia and sheer battle fatigue, the majority of the seriously wounded have required surprisingly little analgesic medication during the first 18 to 24 hours postoperatively. After this period, morphine in doses of grains 1/6 to 1/4 every three to four hours may be required for another 48 hours. After the second or third day, codeine by mouth should be substituted as much as possible. There has been a tendency to administer morphine somewhat longer than necessary, particularly if the orders are written as "p.r.n.". In thoracic cases where morphine is given more for its sedative than analgesic effect, it was found wise often to prescribe this drug in smaller and less frequent doses than for the abdominal wounds to avoid depression of respirations and the cough reflex. The anoxia inherent in thoracic cases may be seriously increased by this depression. The same caution was found to be appropriate in maxillofacial cases. Codeine hypodermically and barbiturates usually were effective analgesics and sedatives in head injuries and avoided the respiratory depressant and "symptom-masking" action of morphine.

Barbiturates have been very useful to complement the action of morphine. During the later postoperative periods they have been effective alone as hypnotics and to allay apprehension particularly when forward hospital areas were subjected to enemy artillery and air attack.

OXYGEN ADMINISTRATION

Anoxia of varying degree was a frequent finding in the seriously wounded. It was particularly notable in thoracic wounds as an expression

of altered respiratory function, but was encountered also in patients with serious abdominal wounds. Curtailment of respirations by pain and the mechanical compression of the lungs by abdominal distension were important causes of pulmonary anoxia in such cases.

Prolonged shock in any seriously wounded case caused circulatory anoxia and in turn was increased by it. In these patients, particularly, morphine given to allay pain and restlessness tended to increase the anoxia by depressing the respirations. Dyspnoea or tachycardia are positive indications for administration of oxygen. One should not wait for development of cyanosis which is a late manifestation.

Oxygen administered by nasal catheter or mask was utilized almost routinely by many of our surgeons to combat this anoxia. Through a soft #10 or #12 French catheter, six to eight liters of oxygen per minute could be administered to the patient for several days when indicated. Multiple small perforations in the catheter near its tip and an efficient humidifying bottle inserted in the oxygen line will greatly enhance the patients tolerance of the treatment. The catheter should be cleaned at least once daily and changed to the other nostril. Masks of the BLB type were available when higher concentrations of oxygen were desired or the nasal catheter was tolerated poorly.

The success of this oxygen treatment was made quickly apparent in many patients by improvement in their shock, relief of dyspnoea and allayment of restlessness. We feel that less immediate and less obvious benefits, such as improved resistence of tissues to infection and improved oxygenation of extremities with locally impared circulation also resulted from continued oxygen therapy. In general, oxygen, whether used prophylactically or for specific indications, proved a valuable aid to treatment in the forward hospitals.

BLOOD COUNT AND HEMOGLOBIN

Despite administration of large quantities of whole blood in the treatment of shock and acute anemia due to initial blood loss, some anemia was apparent not infrequently during the postoperative courses. At times this became aggravated by sepsis or secondary hemorrhage. Using the hematocrit red blood count and hemoglobin determinations as guides, additional blood transfusions were given as indicated. The importance of a normal hemoglobin level in relation to tissue oxygenation is well known. Little benefit could be derived from the administration of iron by mouth during the relatively short forward hospital treatment periods.

NUTRITION AND PROTEIN BALANCE

The majority of battle casualties appeared in a good state of nutrition and were maintained so by administration of blood, plasma, and diet as tolerated postoperatively. Only in the cases with protracted complications did gross nutritional deficiency develop and present problems in treatment. The reduction in plasma proteins in the injured patient was rarely severe and the body reserves were able to maintain a normal plasma protein volume in most cases. In rare instances of more severe protein loss, however, certain complications, such as pulmonary edema and infection and wound disruption seemed favored. It was found helpful to obtain protein determinations* on the blood serum in such cases and to treat vigorously as indicated.

The available means of preventing such protein deficiency states in forward hospitals was limited to the use of whole blood, blood plasma and amino acid preparations. The latter were administered to a few patients and were discontinued after a fatality attributed to the preparation in use. It was rarely possible to obtain any form of specialized high protein liquid diet for these patients in the forward hospitals and nearly complete reliance was made upon the above-mentioned intravenous preparations.

VITAMIN LEVEL MAINTENANCE

The parenteral use of vitamins was largely limited to vitamins B and C. The known beneficial effect of vitamin B in regeneration of red blood cells and in maintenance of intestinal tone and the importance of Vitamin C in wound healing and increasing resistence to infection seemed to justify their use. Furthermore, buccal signs of early vitamin B and C deficiency have been observed in a significant number of wounded and otherwise normal soldiers overseas. Some surgeons prescribed preparations of these two vitamin complexes routinely while others reserved their use for patients whose postoperative courses became complicated and protracted. In a few instances of severe liver damage or biliary fistula, vitamin K concentrates were administered in the forward hospitals. Multivitamin preparations were given to nearly all patients as soon as oral intake was permitted.

* The so-called "copper sulfate series" was performed in the laboratories of most of the forward hospitals and provided the surgeon with highly useful figures on the hematocrit, hemoglobin and blood specific gravity in addition to the plasma proteins.

POSTOPERATIVE CARE IN THORACIC WOUNDS

Rational postoperative care of the wounded thorax is based on an understanding of intrathoracic traumatic pathology and its correction. In many instances of purely thoracic wounds it has been difficult to separate postoperative "complications" from the states arising as a natural evolution of the pathological process.

The three main objectives of postoperative care in thoracic cases are: Attainment of prompt and complete pulmonary re-expansion; maintenance of a patent air way; and relief of pain.

Early pulmonary re-expansion is of primary importance in the prevention of empyema and the restoration of normal intrathoracic physiology. This view was foreshadowed following World War I by Yates[1] who stated "resistence of serous activities (i.e. serosal surfaces) is commensurate with their ability to maintain their mesothelial surfaces in approximation". All air and fluid should be removed from the pleural cavity as rapidly as possible. There are no indications for air-replacement. When drainage has been employed the tubes should be "milked" at least once or twice daily to maintain patency. They should be removed promptly when they have ceased to function. Major adjustments and irrigations of drainage tubes increase the dangers of infection and should be avoided. If there are residual fluid collections, thoracentesis should be done. When the chest has not been drained, thoracentesis should be continued daily, as long as 100 c.c. or more of fluid or air is obtained. Frequent roentgenograms are necessary in determining the status of the lung.

Increased bronchopulmonary secretions and blood resulting from trauma to the lung are of common occurrence postoperatively and must be considered part of the original pathology. Purulent bronchial secretions at this time nearly always signify a pre-existing bronchitis. The presence of excessive fluid in the bronchi is evidenced by rattling respirations, frequent ineffectual cough, dyspnea, and often cyanosis. These excretions must be evacuated. In every case, ward attendants should periodically support the chest and urge the patient to cough. Hyperventilation and frequent turning are aids. When the patient cannot raise sputum, intratracheal catheter aspiration is indicated (2). The resulting expulsive effort will force small plugs of material out into the larger bronchi where they can be removed by suction. The aspiration may be performed every few hours without ill effect. Bronchoscopic aspiration, which can be performed on the ward under topical anesthesia, should be used if catheter aspiration has not been effective.

The control of postoperative pain has an intimate bearing on the patiant's comfort and on his ability to cough and raise sputum. Regardless of how much bronchial fluid is present, the soldier will not cough

effectively if he has a painful thorax. Much of the pain may have been controlled by crushing or injecting the intercostal nerves at the time of operation. Residual pain can be controlled postoperatively by means of intercostal nerve block, using 1% procain (3), an easy ward procedure. Usually the effects of a single block will last at least 24 hours or longer but the injections may be repeated as often as necessary. In general, morphine is contraindicated for the relief of thoracic pain because of its depressant effect on respirations. Adhesive strapping has been almost completely discarded as inefficient and unphysiological.

Postoperative chemotherapy in thoracic casualties has followed the general trend. Since June 1944, when penicillin became readily available, the routine local and systemic use of sulfa drugs has ceased. In major intrathoracic wounds, penicillin in doses of from 20,000 to 25,000 units has been given intramuscularly every three hours for approximately 10 days following operation. In the majority of thoracotomies, 25,000 units in 25 c.c. of water have been injected into the pleural cavity at the time of closure. Particularly following the debridement of large sucking wounds (traumatic thoracotomy), in the presence of especially heavy contamination or actual infection, we have not hesitated to place from five to 10 grams of crystalline sulfanilamide into the pleural cavity and wound in addition to penicillin. Twenty-five thousand units of penicillin may be injected at the time of periodic thoracentesis, particularly if the wounds in general are contaminated or infected.

POSTOPERATIVE INTRATHORACIC COMPLICATIONS

Postoperative pulmonary, or, more properly, intrathoracic complications are important and frequent causes of morbidity and mortality in the war surgery of any region of the body (see Table I). As stated above, in thoracic casualties the postoperative intrathoracic complications often may be indistinguishable from the original pathology. When such complications do arise however, their treatment is exactly the same whether they occur in an already injured lung, or in a normal lung following operation for other wounds. In the following paragraphs all complications will be discussed without regard to whether or not a thoracic injury was present.

Pulmonary Complications:

Atelectasis. Lobar or total pulmonary atelectasis was a rare complication. Patchy or lobular atelectasis probably occurred with great frequency but often it was difficult if not impossible to distinguish it roentgenologically from an area of pulmonary contusion. Occasionally when dyspnea was out of proportion to the size of the roentgen shadow in the lung, atelectasis could be suspected. Of whatever degree, atelectasis in our experience always has been caused by excessive fluid accumulation completely obstructing a bronchus. These excretions were mainly

from an injured lung, a pre-existing bronchitis, or the result of prolonged ether anesthesia. The <u>prevention</u> of atelectasis rests on the various measures which will keep the air-way clean and dry as outlined above. The treatment of a well-defined atelectasis consists of greater efforts in aiding the patient to expell fluid from his bronchial tree, and in the early and repeated use of bronchoscopy if other means fail.

<u>Aspiration of Vomitus</u>. This is a serious complication and demands special attention. It can be prevented to a large extent if the stomach is emptied routinely in the shock tent and the tube left in place during operation. Stomach contents are very irritating to the respiratory tract and their presence excites a rapid and severe exudative chemical bronchitis and bronchiolitis. Immediate bronchial obstruction may develop, especially if food material has been aspirated. When aspiration of vomitus occurs before the patient has completely reacted from anesthetic (the usual time, he will not co-operate and no time should be wasted in attempts at getting him to cough voluntarily. We believe immediate bronchoscopy to be the safest and most efficient procedure. Prior to bronchoscopy, atropine, grains 1/100 should be injected intravenously if none has been given within an hour. This minimizes the dangers of sudden cardiac arrest from a hyperactive vago-vagal reflex. Bronchoscopy allows for visualization and facilitates the removal of particulate matter. When bronchoscopy cannot be done, thorough tracheo-bronchial catheter aspiration should be carried out at once. If fatal asphyxia does not occur, a fulminating pneumonitis frequently follows failure to remove aspirated vomitus.

<u>Pneumonitis</u>. The infectious pulmonary complications have been diagnosed as bronchopneumonia, lobar pneumonia, pulmonary consolidation, etc. The diagnosis has been based on the development of toxicity, increased fever, pulmonary signs of consolidation, and autopsy findings in fatal cases. It is of interest that in comparing patients with thoraco-abdominal and intrathoracic wounds, the percentage of infectious complications was practically equal in the two groups. In nearly all instances the pneumonitis developed on the basis of stagnation of excessive bronchial fluid, atelectasis, and a secondary infection. In the winter months especially, pre-existing purulent bronchitis was an important source of the infection. In a few instances, lobar consolidation appeared as the primary pathology, without a previous diagnosis of atelectasis. Sulphadiazine was the drug of choice, and often, when a pneumonia developed under penicillin therapy, it responded promptly to sulfa administration. In many cases the stagnation of bronchial secretions persisted and both catheter suction and bronchoscopy were employed if the patient could not cough effectively, <u>even though undoubted pulmonary infection was already present</u>.

Pulmonary Edema. This occurred in patients both with thoracic and nonthoracic wounds, but it was impossible to distinguish the causative factor in many instances. In some cases with severe pulmonary contusion an early edema developed. As Drinker and Warren[4] hav pointed out, pulmonary transudates (i.e. edema fluid) are caused also by dyspnea and by anoxia. In other cases the edema probably was due to the too rapid administration of large volumes of intravenous fluids. A small percentage of these patients manifested signs of right heart failure (hyperpnea, distended neck veins and falling systolic and pulse pressures). Prompt venesection of from 500 to 750 c.c. was necessary when right heart failure was obvious. In the fracture group, some of the cases of pulmonary edema undoubtedly were secondary to pulmonary fat embolism. Delayed edemas, developing from five to 10 days after injury, usually were associated with anuria.

Since pulmonary edema frequently was secondary to other pathology, specific treatment was in the main unsatisfactory, and often failed entirely. Efforts always were made to increase tissue oxygenation. Atropine sulphate, grain 1/100, given intravenously apparently benefitted a few cases. When frothy pulmonary secretions were excessive, tracheobronchial catheter suction was used repeatedly. At times, a small catheter was left indwelling in the trachea and oxygen administered between aspirations. In a few cases, oxygen given under positive pressure through a mask was of distinct benefit.

Pulmonary Embolism. This frequent complication was often fatal. In some cases the diagnosis could be made clinically; in many, however, embolism was an autopsy finding.

As in civilian experience, the majority of the emboli, fatal and nonfatal, arose in the deep veins of the lower extremities. In a partial review of cases of phlebothrombosis found in the seriously wounded patients listed in Table I, Gumness[5] noted eleven cases of fatal embolism with origin of the emboli in the deep veins of the lower extremities. None of these had been treated surgically for the phlebothrombosis. In six other cases, femoral veins were ligated after evacuations of thrombi. Pulmonary embolism occurred in only one of these six cases and was not fatal. Of special interest was the fact that, of the 17 total cases of phlebothrombosis listed by him, the patients had sustained direct wounds of the involved lower extremity in all but three. Infection appeared to be a factor in some of these cases. In a few instances of severe wounds of the lung, pulmonary vessel thrombosis was described, but no case of retrograde embolism to the contralateral normal lung was recognized.

No consideration need be given to the operative treatment of embolism in the group of patients under discussion. The treatment frequently described for similar cases in civilian practice can be applied under war conditions, but it has not been used in its entirety. Briefly, this consists of upright position in bed, oxygen administration, and the intravenous injection of atropine, grains 1/75 and papaverine hydrochloride,

grains 1/2, three or four times a day. Prophylaxis is greatly preferable. It is only fair to say that many factors in forward hospitals have combined to cause some neglect of prophylactic measures. The patient's position should be changed frequently, both from side to side and with head both raised and lowered. He should not be left in Fowler's position indefinitely as this will tend to cause some obstruction to the return flow of blood from the extremities. Whenever possible, simple muscular exercise of the foot, leg and thigh should be carried out several times a day.

The lower extremities should be examined routinely but carefully in these seriously wounded patients for evidence of phlebothrombosis and thrombophlebitis of the deep veins. If such becomes evident, whether or not nonfatal pulmonary embolism has occurred, we feel that the femoral or iliac veins should be ligated promptly above the thrombus. The clot may be evacuated if it seems appropriate. Such treatment of the vein appears to be the only relatively certain method of preventing subsequent embolism in these cases.

Heparin and Dicoumarin were not available in the forward hospitals.

Pulmonary Fat Embolism. The rate of occurrence of this complication cannot be stated with accuracy but it is believed to be relatively high. Clinical diagnosis is almost impossible in the presence of intrathoracic wounds. In fatal cases, microscopic evidence of fat is necessary if there is concomitant pulmonary injury. Given a patient with a major fracture and a previously normal chest, however, pulmonary fat embolism may be diagnosed clinically with some accuracy. Within a few hours to several days after injury there may develop thoracic discomfort, a rapid pulse, dyspnea, cyanosis and scattered fine rales, especially at the bases. The patient may die rapidly from asphyxia. Supervening amnesia, muscular twitchings, mental confusion, and even coma are characteristic of cerebral involvement. There is no specific treatment. Oxygen should be administered in liberal amounts and the patient kept quiet. Prophylaxis is of great importance and starts on the battlefield. Secure immobilization and gentle handling of fractured bones are essential. After admission to the hospital, the limb should be moved as little as possible and roentgen examination done with splints in place. Even on the operating table, manipulations which displace the bone should be kept to the minimum.

Pulmonary Abscess. All types of pulmonary abscess are uncommon in forward hospitals. Distinction must be made between the abscess developing from aspiration (the usual civilian type) and the traumatic abscess, usually due to the passage of a missile through, or lodgement in, the lung. In the latter category there is evidence to suggest that in some cases at least, pulmonary vascular thrombosis from trauma is an important predisposing factor. Many of the "traumatic" abscesses surround a residual

foreign body. Treatment is aimed at securing adequate bronchial drainage and re-expanding the lung immediately if it is collapsed. Unless there is marked toxicity or recurring hemorrhages, or unless the abscess ruptures into the pleural cavity and the prostration is profound, no surgery should be attempted in forward hospitals either to drain the abscess or to remove the offending foreign body. Patients should receive priority evacuation to a base section thoracic center. There is a third type of abscess which is encountered with great rarity and has an identical civilian counterpart. This type is associated with blood stream infection, is embolic in nature and usually multiple. Little can be done and the prognosis is extremely poor.

Bronchopleural Fistula. This almost never occurs except in patients with intrathoracic wounds. Usually it is due to a blow-out of previously damaged pulmonary tissue and results in pneumothorax. The majority will not produce intrapleural infection in forward hospitals, unless the fistula itself develops on the basis of an infected missile track. The lung should be immediately re-expanded. If this cannot be accomplished readily by thoracentesis, a small catheter should be inserted in an upper anterior intercostal space and attached to a water-trap bottle. The fistula might be large enough to produce a pressure pneumothorax and an unexpansible lung, but we have not seen this complication. Operation might be necessary under these circumstances for closure of the fistula.

Intrapleural Complications:

Clotted Hemothorax. Blood appears to clot in the pleural cavity with great frequency but this seldom prevents at least partial aspiration in forward hospitals. Rarely (less than 5%) a hemothorax may become completely unaspiratable very soon after injury. This is no indication for emergency surgery. The fact of the clotting should be noted prominently on the chart and the patient evacuated to the base as soon as possible.

Posttraumatic Infection Including Infected Hemothorax and Hemothoracic Empyema. A few patients (less than 5%) will develop early intrapleural infection in forward hospitals. Each case must be treated on its merits. Where the infection is not fulminating and develops in a large hemothorax, priority evacuation should be given to a base thoracic center. In an early, toxic empyema, due for example to the rupture of a pulmonary abscess into the pleural cavity, or the presence of a large bronchial fistula, drainage must be undertaken in a forward hospital. Air-tight rib resection drainage with a water trap is preferable unless the patient is too ill to under go even this minor procedure. In such cases, closed intercostal drainage on the ward may be used as an interim procedure. When rib resection has been done, the drainage may be made open in a short time and the patient safely transported with a tube in his chest. Except under the most unusual circumstances relatively early thoracotomy (five

to 10 days) for decortication of the lung because of massive infected hemothorax or empyema, is not justified in forward hospitals.

Subphrenic Abscess. This rarely develops in patients before they are evacuated. When it occurs, however, drainage should be undertaken according to recognized principles. Every effort must be made not to violate the pleural cavity.

POSTOPERATIVE CARE OF ABDOMINAL CASES

The usual patient with wounds of the abdominal viscera will require postoperatively the continued treatment for "shock" when present, the proper maintenance of his fluid balance and nutrition and blood hemoglobin, and sufficient morphine or other drugs to keep him comfortable as outlined above. He may be benefitted greatly by oxygen administration. It is especially important also, to encourage his moving about in bed and the exercise of his legs beginning at the earliest possible moment. He should be urged to do deep breathing from time to time and to cough frequently if there are excessive pulmonary secretions. The use of nasogastric suction, probably the most important single feature of postoperative management in abdominal cases, is described below. Good nursing care, of course, occupies its usual important place in the treatment of these very sick patients.

For the prevention and treatment of the various complications, special measures are in order.

Abdominal Complications

Ileus. Ileus was present to some degree in all wounds involving the peritoneal cavity and reflexly in some other wounds. Usually, it was of the functional or adynamic type. Several factors contributed to this ileus: Peritoneal contamination and subsequent peritonitis, trauma to the bowel at the time of injury and surgery, presence of retroperitoneal hematomas, and in some cases a peristaltic depressant action of morphine.

The most effective method of preventing or treating this ileus was by the early and continuous use of gastro-duodenal suction (Wangensteen). A Levin tube was passed into the stomach of virtually all seriously wounded patients in the shock ward before anesthesia and proved to be an additional aid in the preparation of these patients for surgery by preventing and relieving gastric dilation. Aspiration of gastro contents, a serious complication in our early experience, was thus largely avoided. Suction was maintained during surgery and for several days thereafter in most abdominal cases. Distention usually could be prevented if adequate suction was maintained.

Figures 6 & 7 - The post operative ward of Field Hospitals

Postoperative Care of the Seriously Wounded; Prevention and Treatment of Complications (Postoperative Care of Abdominal Cases, contd)

Patients were allowed to drink small amounts of water during the postoperative period while the tube was in place. The average abdominal battle casualty required suction for three to six days postoperatively. When the patient began to pass gas freely by rectum or otherwise manifested a return of active peristalsis, the tube could usually be removed with impunity. However, it was found best to clamp it for a number of hours before removal, to be certain that the patient would do satisfactorily without it. After the tube had been removed, the patient was allowed to increase his fluid intake orally as tolerated, and parenteral fluid administration was reduced or omitted. When gastroduodenal suction does not relieve the distension, additional aid may be derived from the use of the Miller-Abbott tube. One must be careful not to persist in the use of such conservative measures when strangulation obstructions or closed loop obstructions are suspected. In such cases early surgical intervention is mandatory.

Peristalsis-stimulating drugs had little value in the treatment of ileus in our series. The use of high concentrations of nasal oxygen in a few cases was not followed by striking results.

Intestinal Obstructions. There were at least 22 cases of postoperative obstructions involving the small intestine. Only five of these cases were re-operated. Conservative measures are appropriate in the early stages of this complication, unless strangulation obstruction or closed loop obstruction is suspected, as stated above.

Peritonitis. The treatment of peritonitis included those measures previously outlined for care of ileus plus the use of penicillin and sulfonamide agents in adequate dosage. Frequent blood transfusions and liberal amounts of intravenous plasma were also helpful. Some degree of peritonitis was present in every abdominal and thoraco-abdominal case and was the principal cause of death in approximately 12% of the fatal group. Localized abscesses in the peritoneal cavity were drained as soon as diagnosed.

Penicillin was administered to nearly all abdominal cases postoperatively after May 1944. The usual intramuscular dose was 25,000 units every three hours, maintained for from five to 10 days or more, depending on the clinical course. In many instances sulfadiazine, parenterally or by mouth, was given also, particularly if there had been fecal contamination of the tissues. A review of this experience has led to the impression that penicillin was a more valuable adjunct than sulfadiazine in the control of peritoneal infection in these cases ("Penicillin and Sulfonamide Therapy in Abdominal Wounds", page 197). The intraperitoneal application of the sulfonamides and penicillin however, seemed to have no effect on the actual mortality rates of wounds of the colon and rectum. (See section on this subject, page 298.)

Postoperative Care of the Seriously Wounded; Prevention and Treatment of Complications (Postoperative Care of Abdominal Cases, contd)

Intestinal Fistulas. There were one gastric, two duodenal, twelve small intestinal, eight large intestinal fistulas recorded as complications during the forward hospital periods. Frequent changes of dressings, protection of the skin by ointments and other medicaments and, rarely, suction were available as local treatments in the forward hospitals. Glucose and saline solutions and protein were required in unusually large amounts parenterally as outlined above to combat loss of these elements in fistula cases. They were evacuated rearward as soon as possible.

Wound Disruption and Infection. Wound disruption occurred 36 times in abdominal cases. (See page 187.) When the general condition of the patient permits, an immediate secondary closure by suture should be made. Rarely, in critically ill patients, adhesive taping may be used to approximate the wound edges. The former practice is preferable for it reduces the chances of adherence of intestinal loops in the incision and the possible subsequent development of intestinal obstructions. Appreciable operative wound infection without actual disruption was seen less frequently. It responded well to reopening of the incision as necessary and to hot, wet or antiseptic dressings.

Secondary Hemorrhage. This complication was seen infrequently, but, when it occurred, presented a serious problem. Six secondary hemorrhages were recorded in cases with gastric lesions, and three of these proved fatal. In one instance, a secondary hemorrhage occurred from a jejunal anastomosis. This patient did not survive the re-operation. Two secondary hemorrhages were seen in cases with extraperitoneal perforation of the rectum. The buttock and rectal wounds were infected and the superior gluteal artery bled severely on the 10th and 12th postoperative days respectively, in these cases. In one case a severe secondary hemorrhage occurred from a wound in the hilum of the liver. This was satisfactorily controlled by laying open the missile tract to the liver and suture-ligating the bleeding artery. There were no recorded cases of secondary hemorrhage following injuries to the kidney. In general, secondary hemorrhages were best treated by prompt operative exposure and hemostasis. Packing for bleeding in wounds of most of the organs was unsatisfactory.

Anaerobic Infections. Anaerobic infections were recorded as either the principal or contributory cause of death in 24 patients with trunk or extremity wounds. The regions involved were: The extremities or buttock in 16 cases; the abdominal wall or retroperitoneal tissues in six cases; the chest wall in two cases. Nearly all of these patients were given vigorous penicillin and serum therapy in addition to appropriate surgical handling. This subject is discussed in detail in the section on "Anaerobic Infections" (page 746).

Other Complications. Urinary tract infection was seen rarely. This was probably due to the frequency with which penicillin and the sulfonamides were administered in treatment of the patients' primary pathology. Suprapubic cystotomy usually was performed for cases in which urinary retention was associated with spinal cord injuries.

Bed sores following cord injuries were difficult to prevent. The main effort was toward elimination of pressure points. Frequent turning of the patient, protection of the heels and buttocks by gauze rings and air cushions, plus constant attention to keeping the skin dry in these areas were the means most readily available in forward hospitals.

DRAINS AND THEIR REMOVAL

Drainage of the general peritoneal cavity was rarely attempted. When inserted, these drains were removed usually on the fourth to tenth postoperative day. Drains used in the surgical care of liver wounds, usually were loosened beginning on the fourth postoperative day and were out completely by the tenth or twelfth postoperative day. However, the presence of biliary drainage is the most important criteria, and no liver drain should be removed until this drainage has ceased. Similar indications for removal apply to drains used for kidney and pancreatic wounds as well as those placed in the space of Retzius.

CARE OF THE COLOSTOMY

Approximately 1200 colostomies were performed in the group of 3154 abdominal cases. From the point of view of obtaining solid healing of the bowel to the abdominal wall and of reducing the possibility of infection, it would have been desirable to leave colostomies closed for several days. This did not seem safe, however, in the majority of exteriorized wounds of the colon and early opening was usually practiced. Even in the proximal diversional colostomies made for wounds of the colon and rectum, peristalsis often returned in less than 48 hours, requiring opening of the colostomies at that time. In the loop type colostomy, the bowel should be opened along its longitudinal axis and with its greater part of the opening proximal to the supporting glass rod or rubber tube. The care of the colostomy in these cases presents few additional problems to those encountered in civilian practice. It is very important to keep the stoma separated from the main laparotomy incision and this can be accomplished by covering the former with adhesive tape and oiled silk anchored to the skin with liquid adhesive. In all cases, the abdomen should be cleaned immediately after the colostomy has functioned. This is particularly necessary where a thoracobrachial or hip-spica cast has been applied for associated extremity pathology. There is considerable psychological value to the patient, also, in good colostomy care.

LOCATION OF FORWARD HOSPITALS
Effect on Patient

The surgeons of this Group have been impressed by the importance of the tactical disposition of the forward hospitals (usually single platoons

of Field Hospitals) in relation to the medical progress of the patients postoperatively. If the hospital was located near an artillery emplacement or an important supply junction which drew enemy shell fire or air attack, the patients were highly apprehensive and restless. Under such conditions, badly needed rest was impossible and progress was retarded correspondingly. Though proximity of these hospital units to the combat area is important in permitting rapid evacuation and early definitive surgery, our experience has shown that the patient's recovery is enhanced by placing the unit a little farther to the rear or in a quieter area whenever possible.

THE FORWARD HOSPITAL TREATMENT PERIOD

The matter of how long these first priority surgical cases should be held in the forward hospitals after operation was of great importance and had to be learned by experience. It was found that transportation of these patients could be carried out with the least untoward effects during certain periods of their postoperative courses. Except when the tactical situation forced the surgeon's hand the following periods of treatment and observation in the forward hospitals were found generally advisable:

1. Abdominal cases -- eight to ten days
2. Chest cases with thoracotomy -- seven to nine days
3. Extremity wounds with circulatory deficiency -- held until viability of limb was determined and likelihood of fulminating gas gangrene minimized -- four to five days
4. Major compound fractures in the absence of peripheral circulatory deficiency -- two to three days
5. Head and maxillofacial injuries -- transportable as soon as shock was overcome and patient's condition generally stabilized with assured air way.

These time intervals represented the minimal ones desirable and were subject to considerable modification by the condition of the individual patient.

SUMMARY

1. The nature and degree of the problem involved in postoperative care of the seriously wounded and the handling of complications has been illustrated by a tabulation of principal causes of death in a large series of wounds and injuries involving the trunk and extremities (Table I, this paper).

Postoperative Care of the Seriously Wounded; Prevention and Treatment of Complications (Summary, contd)

2. Next to persistent shock, which was not a true complication, intrathoracic complications constituted the largest group of principal causes of death.

The importance of trauma to the lungs and other chest structures in the development of pulmonary atelectasis is emphasized. The further relationship of atelectasis to the so-called "infectious pulmonary complications", is stressed also.

3. Abdominal complications, notably peritonitis, occupied important roles in the postoperative courses of abdominal wound cases, and virtually none in purely thoracic or extremity wounds.

4. The routines of postoperative care of the seriously wounded as practiced by teams of the 2nd Auxiliary Surgical Group, are presented with special emphasis on measures toward prevention and treatment of the various complications encountered.

5. Since the postoperative care of patients with wounds of the central nervous and genito-urinary systems, and with maxillofacial and extremity wounds is described in detail in other sections (pages 746, 621 & 593), it has been omitted from this discussion.

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WOUNDS OF THE ABDOMEN:

AN ANALYSIS

OF 3154

CASES

WOUNDS OF THE ABDOMEN - AN ANALYSIS OF 3154 CASES

INTRODUCTION

The concepts regarding the proper treatment of casualties having abdominal wounds have undergone a remarkable and radical change during the past 20 years. Bailey[1] has pointed out this change in concepts. During the period from the Boer War (1899-1901) until 1915, the accepted principle followed in war wounds of the abdomen was one of strict surgical nonintervention. Thereafter the policy of noninterference began to be questioned in the minds of many men, and by the end of World War I, it was more or less generally agreed that most abdominal injuries should be treated by operation, although lack of organization prevented this course from being followed as widely as was desired. It is of interest to note that as late as the Spanish Civil War (1936-1938), even though the need for surgical intervention in abdominal wounds was generally accepted, 50% of patients having such wounds were denied the benefits of surgery (Matas)[2]. This appalling situation apparently resulted either from lack of personnel and equipment to handle these severely wounded individuals, or else the casualties were adjudged to have wounds of such severity as to preclude operation.

The concept of the treatment of the abdominal casualty, as it exists and is practiced today, is one which denies surgery to no case on the grounds of severity of wounds. Exact figures are not available, but it is certain that far less than 1% of cases in this series were deemed too severely wounded to be denied the benefits of surgery. Resuscitation measures were invariably and vigorously begun in all patients, no matter what the condition on admission, with the anticipation that surgery was to be done. A small percent of total cases failed to respond and died during the resuscitation period, but the ultimate goal in every case was the benefits of surgery.

This non-selection of cases inevitably led to an increase in mortality rate, especially in regard to deaths during the induction of anesthesia, and during surgery. However, in none of the 756 deaths recorded was it felt that surgery was responsible for the death, and in almost every case it was certain that death would have followed inevitably had operation not been undertaken. A gratifyingly large number of very severely wounded patients survived their wounds because of surgery, death being the only alternative had surgery been denied them.

The need for a small mobile surgical unit, placed well forward, and having highly trained and well qualified personnel for the early treatment of abdominal wounds is unquestioned, but only from a humanitarian motive, but also because of the effect on morale. Troops in the line

have known that there have always been near at hand facilities for their care should they be wounded, and that their priority for treatment would be proportionate to the severity of their wounds. The effect on troop morale of this knowledge has been large, and has frequently been commented upon by both soldiers and officers of the line, whether wounded or not.

Many patients with abdominal wounds, although acutely and critically ill for the first few days, ultimately make a complete recovery, without, we believe, crippling or disabling sequelae. Of the 3532 patients with abdominal wounds treated by this Surgical Group, it is probable that most were saved from certain death, and it is expected that most of these will have no physical abnormalities other than some scars.

The exact proportion of abdominal wounds to wounds of other regions of the body is not known, but it is believed that patients with abdominal wounds make up a very high proportion of the critically wounded seen in hospitals. The salvaging of these cases materially reduces the mortality rate of any Army.

SCOPE OF SURVEY

This report is based solely upon 3154 cases of abdominal injury treated by the surgeons of this organization in forward surgical installations. These cases include all casualties so treated in which trauma was sustained incident to the violence of warfare. Wounded civilians, Allied soldiers, and prisoners of war are included and together comprise slightly more than 15% of the entire series.

Cases operated upon by surgeons on temporary duty with this command have been excluded. Statistics and statements regarding deaths and complications apply only to those observed in the hospitals of original treatment. No follow-up data are included.

The source material for this study has been the individual case records prepared by the surgeons for the files of the Group. Due to uncontrollable factors resulting from military stress, the data in all records are not complete, and for this reason, certain apparent statistical discrepancies will be noted.

Opinions expressed in the section on Abdominal Surgery represent the consensus of the surgeons of the Group, based either on informal polls or on obvious uniformity of practice as reflected in the case records.

Information is included which is not of purely medical import. This information embraces data and statistics of interest from the historical and military points of view.

Wounds of the Abdomen-An Analysis of 3154 Cases. (Scope of Survey, contd)

The majority of the cases reported, 2851 or 90.4% were operated upon in Field Hospital Platoons. Two hundred thirty two or 7.4%, received their initial surgery in Evacuation Hospitals. The remaining 2% were treated either in Clearing Stations or Allied Hospitals, or did not have the type of installation recorded.

The numbers of cases treated in the various types of hospitals are tabulated in Table I, together with the mortality rate for each installation. The lower mortality in Evacuation Hospitals as compared with Field Hospitals probably reflects the less severe injuries received in Evacuation Hospitals.

TABLE I

Distribution and Mortality Rates By Hospitals

3154 Abdominal Cases, 1944-45

Type Hospital	No. of Cases	Percent Of All Cases	No. of Deaths	Mortality Percent
Field Hospital	2851	90.4%	693	24.3%
Evacuation Hospital	232	7.4%	35	15.1%
Casualty Clearing Station (British)	58	1.8%	26	44.8%
Clearing Station	10	0.3%	1	10.0%
Not Known	3	0.1%	1	33.3%
Total	3154	100.0%	756	23.9%

Part I of this section deals with general subjects relevant to all abdominal casualties. Statistical data for the series as a whole are presented here and analyzed. Observations regarding missiles, the anatomical sites of entrance of abdominal wounds, and data not purely medical in nature are made here.

In Part II will be found more detailed presentation of specific subjects pertinent to the care of all abdominal wounds, e.g., the problems of shock, incisions, time lag, anesthesia, etc.

Part III presents detailed analyses of frequency, mortality, and methods of management of injuries to the individual viscera.

WOUNDS OF THE ABDOMEN

Part I

General Subjects Relevant to All Abdominal Wounds

Abdominal Injuries, Part I. Presentation of Data.

TYPES OF CASES

The 2nd Auxiliary Surgical Group has operated upon 3532 patients for abdominal injury.

All patients having, or suspected of having abdominal visceral injury are included in the report. Hence, thoraco-abdominal wounds, extraperitoneal injuries to abdominal viscera (e.g., extraperitoneal rectal wounds), negative exploration, intraperitoneal visceral injury without penetration of a missile, and peritoneal penetration without visceral injury are all submitted and analyzed, since no clear cut differentiation exists between these groups of cases. The number of cases in relation to year and campaigns is given in Table II.

TABLE II

Abdominal Cases Treated: Years and Campaigns

Year	Campaigns	Total Cases
1943	Tunisian, Sicilian and first four months of the Italian Campaign	378
1944	Fifth and Seventh Armies	2383
1945	Fifth and Seventh Armies	771
Total Cases		3532

Previous detailed reports have been submitted by members of this Group on the Tunisian Campaign and on the 1943 abdominal cases. Consequently, these cases have not been included in the present report, and are not alluded to in subsequent statistics and opinions except for the sake of comparisons. Therefore, all statistics are based on the 1944-1945 case reports, the number being 3154.

INCIDENCE OF ABDOMINAL WOUNDS IN GENERAL

No figures are available to show the absolute incidence of abdominal wounding, nor are data available to us for comparative incidence of abdominal wounds in relation to wounds of other parts of the body. All of the statistical material gathered in this study is heavy weighted by a preponderance of first priority casualties. However, it is estimated that 50% of patients admitted to Field Hospitals have abdominal wounds.

Abdominal Injuries, Part I. Presentation of General Data.

GROSS STATISTICS - PRESENT STUDY

Total Cases by Years.

All statistics quoted hereafter are based on the study of the 1944 and 1945 records.

TABLE III

Total Number of Abdominal Cases Including Thoraco-Abdominal Wounds By Years and Mortality

Year	Cases	Lived	Died	Mortality Rate*
1944	2383	1797	586	24.6%
1945	771	601	170	22.0%
Totals	3154	2398	756	24.0%

Incidence of Thoraco-Abdominal and Abdominal Wounds.

The following table shows the relative incidence of abdominal and thoraco-abdominal wounds in all abdominal wounds with mortality rates** for each.

TABLE IV

Year	Type of Case	Cases	Died	Mortality Rate
1944	Abdominal	1744	406	23.3%
1945	Abdominal	571	130	22.4%
1944	Thoraco-abdominal	639	180	28.2%
1945	Thoraco-abdominal	200	40	20.0%
Total Abdominal Injuries		2315	534	23.1%
Total Thoraco-Abdominal Injuries		839	222	25.3%

*This mortality figure is based on known deaths occurring in the forward hospitals in which the initial surgery was done. For corrective factors see Page 118.

**Slight discrepancies will be noted in relation to the section on thoraco-abdominal injuries. See Page 112.

Abdominal Injuries. (contd)

Negative Explorations.

Included in the abdominal cases are a number of negative explorations. Fifty-nine of these negative explorations were in the presence of retroperitoneal hematoma. The remainder was performed because of doubt regarding the penetration of missiles.

TABLE V

Negative Explorations

Year	Cases	Percentage of Total Cases	Deaths	Percent Mortality
1944	153	6.4%	8	5.2%
1945	42	5.4%	2	4.7%
Total	195	6.2%	10	5.1%

In addition to the negative explorations, there was a group of 41 cases which had penetration of the peritoneal cavity without visceral damage, with two deaths. Therefore, there was 2918 patients with visceral injury, having a mortality rate of 25.5%.

Incidence of Viscus Wounding.

A summary of the incidence of wounding of various organs is listed below (Tables VI, VII, & VIII).

TABLE VI

Incidence of Wounding of Abdominal Organs - 3154 Cases

Organ	No. Cases	Incidence in 3154 cases
Stomach	416	13.2%
Duodenum	118	3.7%
Jejunum - Ileum	1168	37.0%
Colon and intraperitoneal rectum	1106	35.0%
Rectum (extraperitoneal)	155	4.9%
Liver	829	26.7%
Gall Bladder and Bile duct	53	1.7%
Spleen	341	10.8%
Kidney	427	13.4%
Ureter	27	0.8%
Urinary bladder	155	4.9%
Pancreas	62	1.9%
Major abdominal vascular injury	75	2.4%

Abdominal Injuries. (Incidence of Viscus Wounding, contd)

TABLE VII

Incidence of Uncomplicated Wounding in Relation to Total Wounding of the Various Abdominal Viscera*

Organ	No cases	Incidence
Stomach	42	10.1%
Duodenum	2	1.6%
Jejunum-Ileum	353	30.2%
Colon and intraperitoneal rectum	251	22.7%
Rectum (extraperitoneal)	64	14.3%
Liver	339	40.8%
Gall bladder and bile ducts	0	.0%
Spleen	100	29.3%
Kidney	56	13.1%
Ureter	1	3.7%
Urinary bladder	21	13.5%
Pancreas	1	1.6%
Major abdominal vascular injury	8	10.7%

TABLE VIII

Incidence of Complicated Injury in Relation to Total Wounding in The Various Abdominal Viscera

Organ	No. Cases	Incidence
Stomach	374	89.9%
Duodenum	116	98.4%
Jejunum-Ileum	815	69.8%
Colon and intraperitoneal rectum	855	77.3%
Rectum (extraperitoneal)	91	58.7%
Liver	490	59.2%
Gall bladder and bile ducts	53	100.0%
Spleen	241	70.6%
Kidney	371	86.9%
Ureter	26	96.3%
Urinary bladder	34	86.5%
Pancreas	61	98.4%
Major abdominal vascular injury	67	89.3%

*Throughout the abdominal section, for the sake of uniformity, the term "Uncomplicated" alludes to injury to a single abdominal viscus, whereas "Complicated" refers to the wounding of two or more viscera.

Abdominal Injuries. (Incidence of Visous Wounding, oontd)

TABLE VIII

Incidence of Complioated Injury in Relation to Total Wounding in the Various Abdominal Viscera

Organ	No Cases	Incidence
Stomach	374	89.9%
Duodenum	116	98.4%
Jejunum-Ileum	815	69.8%
Colon and intraperitoneal rectum	855	77.3%
Rectum (extraperitoneal)	91	58.7%
Liver	490	59.2%
Gall bladder and bile ducts	53	100.0%
Spleen	241	70.6%
Kidney	371	86.9%
Ureter	26	96.3%
Urinary bladder	34	86.5%
Pancreas	61	98.4%
Major abdominal vascular injury	67	89.3%

It is readily apparent from a study of the above tables that the frequency of wounding of an abdominal organ is almost directly proportional to the size of that organ. Likewise, it is obvious that the incidence of uncomplicated wounds of any given organ is proportional to the area of that organ in contact with the abdominal wall. An aphorism of modern warfare might well be stated: The incidence of wounding of any given abdominal organ is directly proportional to the space that organ occupies. The truth of this statement is apparent when one considers that 69% of all abdominal wounds in this series were produced by unaimed fragmentation missiles, while the remaining 31% incurred from bullets were for a goodly part from roughly aimed automatic weapons. Even the most finely sighted sniper's bullet was not fired with selective intention toward a single abdominal viscus. It follows, therefore, that any variation in incidence from the maxim stated above probably indicates that patients with certain lesions are not being seen alive. A striking example of this variation, as pointed out in the abdominal vasoular injury discussion (Page 394) is seen in the comparison of incidence of wounds of the aorta and vena cava. Thirty-seven vena caval lesions were seen; no abdominal aortic lesions were seen.

The comparative tables of incidence given below indicate an important point. It will be noted, in general, that frequency of wounding of all organs is considerably higher, and that the proportion of uncomplicated to complicated wounds has been remarkably changed in this series as compared to those formerly reported.

Abdominal Injuries. (contd)

TABLE IX

Comparative Statistics of Incidence of Abdominal Visceral Injury

Source		Percent of Total Cases	Percent of Uncomplicated Cases	Percent of Complicated Cases
Stomach:				
	World War I (USA)[3]	7.0%	66.6%	33.3%
	Wallace [4]	8.5%	68.3%	31.7%
	Ogilivie[5]	5.8%	43.0%	57.0%
	Jolly [6]	8.3%	Not given	Not given
	Present series	13.2%	10.1%	89.9%
Small Intestine:				
	World War I (USA)	22.0%	Not given	Not given
	Wallace	37.6%	70.3%	29.7%
	Ogilivie	34.8%	73.0%	27.0%
	Jolly	31.5%	Not given	Not given
	Present series	37.0%	30.2%	69.8%
Colon:				
	World War I (USA)	22.0%	Not given	Not given
	Wallace	Not given	60.0%	40.0%
	Ogilivie	34.4%	72.5%	27.5%
	Jolly	21.4%	Not given	Not given
	Present series	35.0%	22.7%	77.3%
Liver:				
	World War I (USA)	13.3%	75.0%	25.2%
	Wallace	16.8%	90.8%	9.2%
	Ogilivie	11.3%	85.6%	14.4%
	Jolly	15.9%	Not given	Not given
	Present series	26.7%	40.8%	59.2%
Spleen:				
	World War I (USA)	1.0%	Not given	Not given
	Wallace	5.6%*	59.3%	40.7%
	Ogilivie	5.3%	75.0%	25.0%
	Jolly	4.5%	Not given	Not given
	Present series	10.8%	29.4%	70.6%
Kidney:				
	World War I (USA)	6.3%	50.0%	50.0%
	Wallace	7.5%	Not given	Not given
	Ogilivie	5.3%	70.0%	30.0%
	Jolly	8.0%	Not given	Not given
	Present series	13.4%	13.1%	86.9%

*5.6% - Estimate.

Abdominal Injuries. (contd)

Other organs follow much the same pattern as the above.

It is clearly evident from the comparative figures that in these campaigns a much higher proportion of the severely wounded (men with multiple visceral wounds) were being seen and operated upon at the forward hospitals. No other explanation is possible to account not only for the overall increase in incidence, but also more particularly for the marked change in the complicated-uncomplicated ratio. It is believed that the figures presented in this report much more closely approximate the true incidence of wounding of the various organs than do those previously reported. Even these figures are actually below the absolute incidence.

That so many more of the seriously wounded were seen at the first hospitals is difficult to explain. Certainly all credit belongs to the medical personnel and the evacuation system in echelons forward of the hospitals for bringing about this remarkable accomplishment.

Incidence of Wounding In Relation to Type of Organ Injured.

Table X indicates the incidence and mortality of wounds to solid viscera (either singly or in combination), to hollow viscera (either singly or in combination), or to various combinations of solid and hollow viscera.

TABLE X

Type of Organ Involved

	Cases	Deaths	Percent Mortality
Solid viscera only	668	94	14.1%
Hollow viscera only	1512	352	23.3%
Both solid and hollow viscera	672	269	40.0%

Caution must be used in accepting the mortality data given above without considering the effect of the "multiplicity factor" discussed on Page 109. A more accurate mortality rate is shown by comparing single viscus injuries. For single hollow viscera the mortality rate was 17.4%; for single solid viscus the rate was 11.1%. The combination solid and hollow visceral mortality rate reflects the effect of multiplicity of injuries, rather than any inherent danger in such combinations.

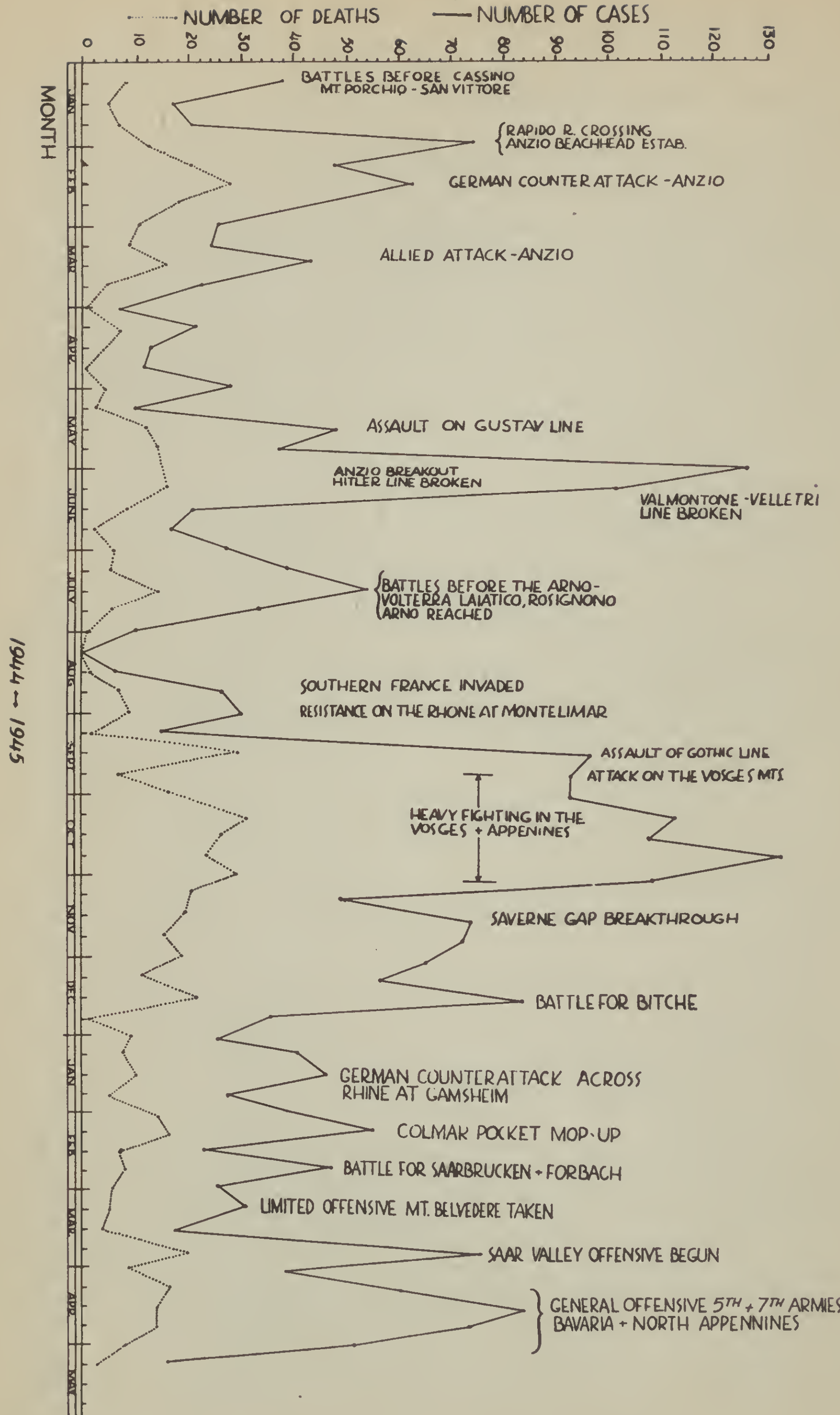
NUMBER OF DEATHS
NUMBER OF CASES
0 10 20 30 40 50 60 70 80 90 100 110 120 130
MONTH
1944 – 1945
BATTLES BEFORE CASSINO
MT. PORCHIO - SAN VITTORE
RAPIDO R. CROSSING
ANZIO BEACHHEAD ESTAB.
GERMAN COUNTER ATTACK - ANZIO
ALLIED ATTACK - ANZIO
ASSAULT ON GUSTAV LINE
ANZIO BREAKOUT
HITLER LINE BROKEN
VALMONTONE - VELLETRI
LINE BROKEN
BATTLES BEFORE THE ARNO -
VOLTERRA LAIATICO, ROSIGNONO
ARNO REACHED
SOUTHERN FRANCE INVADED
RESISTANCE ON THE RHONE AT MONTELIMAR
ASSAULT OF GOTHIC LINE
ATTACK ON THE VOSGES MTS
HEAVY FIGHTING IN THE
VOSGES + APPENINES
SAVERNE GAP BREAKTHROUGH
BATTLE FOR BITCHE
GERMAN COUNTERATTACK ACROSS
RHINE AT GAMSHEIM
COLMAR POCKET MOP-UP
BATTLE FOR SAARBRUCKEN + FORBACH
LIMITED OFFENSIVE MT. BELVEDERE TAKEN
SAAR VALLEY OFFENSIVE BEGUN
GENERAL OFFENSIVE 5TH + 7TH ARMIES
BAVARIA + NORTH APPENNINES

Figure 8

Abdominal Injuries. (contd)

Analysis of 1944 and 1945 Campaigns, Monthly and Seasonal Variations in Abdominal Wounds and Mortality.

It is apparent from Figure 8 that the number of abdominal wounds varied directly with the fury of the fighting, each offensive and lull being mirrored by the number of casualties treated. It is quite likely that the curve of abdominal casualties closely parallels the incidence of casualties in general. The incidence and mortality rates are plotted in actual numbers in Figure 8 and hence do not show the parallel courses of the two curves that would be apparent if they were plotted on arithmo-logmarithmic paper.

It has long been observed from a clinical point of view that patients arrive at Field Hospitals in a more severe state of shock during the cold, wet months of winter than do similar cases in the summer months. Moreover, infections and pulmonary complications, as shown in the postoperative statistics on Page 207 are 30% higher in winter than in summer. Chronic bronchitis and tracheitis seem almost universally present among the front line infantrymen during winter fighting, and it is not surprising that pulmonary complications follow, with an increased mortality rate. These situations are corroborated by the statistical evidence submitted in Figure 9.

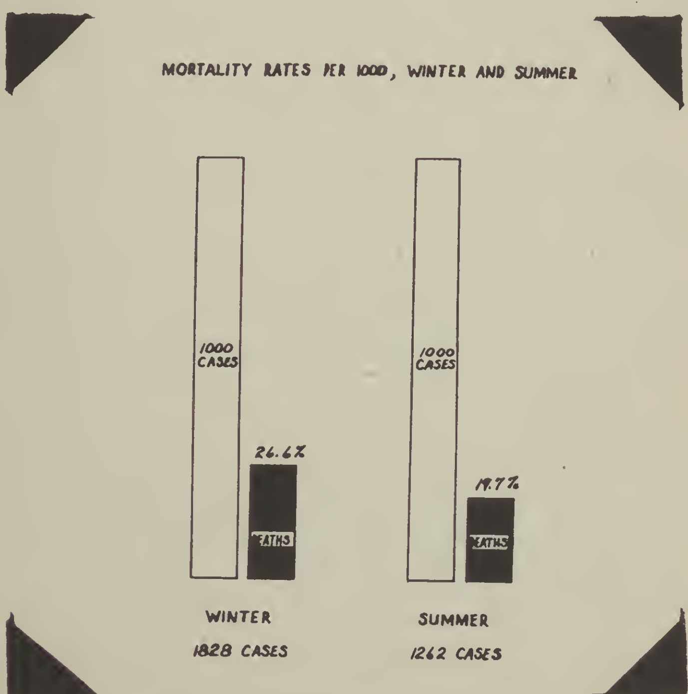

Figure 9 - Mortality - Winter and Summer - 1944 and 1945.

Abdominal Injuries. (contd)

The mortality rate ran higher for the "winter months" (October through March) than for the "summer months" (April through September). Casualties for August were the lowest of any month (see Figure 10), but due to the fact that they occurred almost entirely during the Southern France landings, with the inevitable confusion and delay in establishment of hospital facilities, the mortality rate showed a sharp rise (Figure 10).

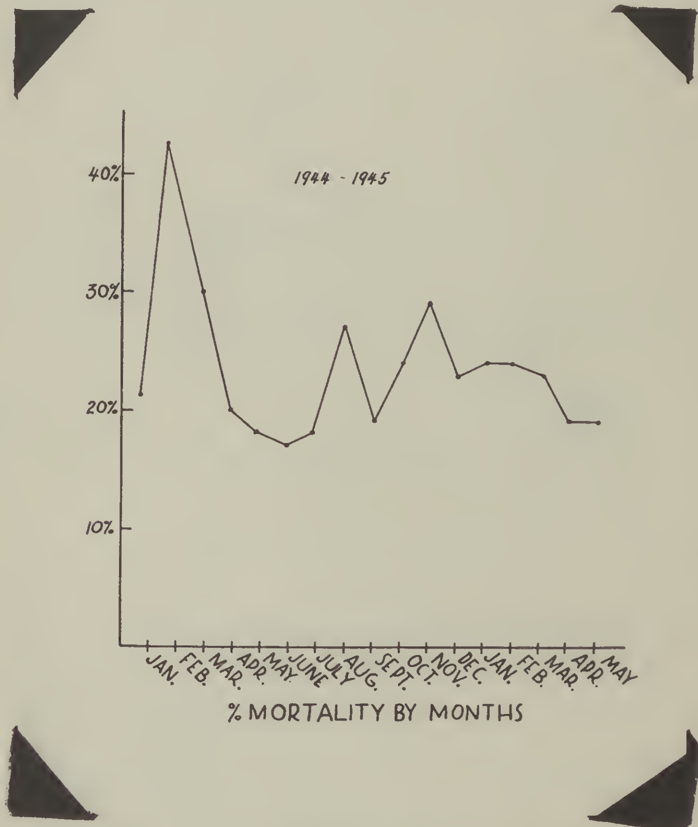

Figure 10 - Mortality by months, 1944-1945.

Table XI shows the incidence and mortality rates by quarters of the year.

Abdominal Injuries. (contd)

TABLE XI

Month	Cases	Deaths	Percent Mortality
January through March	430	141	32.8%
April through June	470	91	19.4%
July through September	503	103	20.5%
October through December	929	232	25.0%

Relation of Branch of Service to Incidence of Abdominal Wounds.

As would be expected, the infantry bore the brunt of the fighting, and consequently the preponderance of casualties occurred in this Arm, (81% of all abdominal casualties among American troops.) All other arms and services had comparatively few wounds of the abdomen. Figure 11 is self-explanatory.

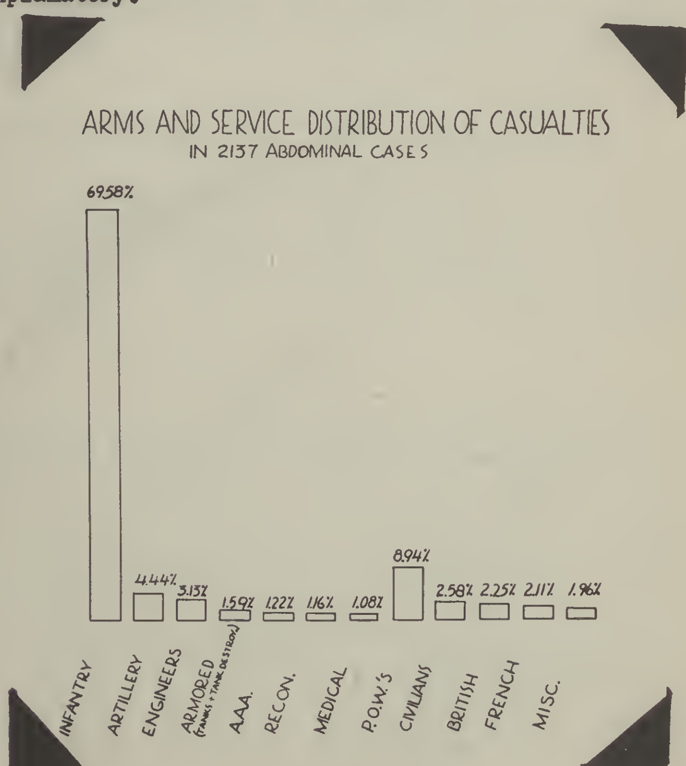

Figure 11 - Arms and Services Distribution of Abdominal Casualties.

Abdominal Injuries. (contd)

Age.

Table XII below shows the effect of age on mortality.

TABLE XII

Incidence of Age Groups and Mortality, 3154 Cases

Age Group	Total Cases	Deaths	Percent Mortality
8 - 20	707	164	23.2%
21 - 25	987	202	20.4%
26 - 30	591	139	23.6%
31 - 35	250	60	24.0%
36 - 40	78	21	26.9%
40 plus	42	18	42.9%
No record of ages	499	152	30.5%

There is a slight, almost insignificant, increase in mortality rate with increasing age in the military group. The rise on either end of the age groups indicates the influence of civilians, - children who were wounded withstood their injuries and surgery poorly, as did the aged. The "no record" group consisted largely of civilians and POW's of whom age was not determined because of linguistic difficulties. The somewhat higher mortality rate is reflected in this group.

WOUNDING AGENTS

There were 3052 patients in this series whose injuries were due to missiles of war; these cases represent 96.8% of all abdominal cases herein reported. High explosive fragments of all types caused 2123, (69.6%) of these wounds, and small arms missiles caused 929, (30.4%). A detailed analysis of the frequencies of wounds caused by the various types of high explosive fragments and bullets is given in Figure

In this large series of casualties it has become apparent that the effects of a given type of missile are by no means invariable. It has been generally true that the wound of entry was smaller than the wound of exit. However, a slender fragment which presents its greatest diameter at the site of entry and makes its exit on a path parallel to its long axis can obviously cause an exception to this statement. Cases have been seen in which the exit wound was the smaller of the two.

Abdominal Injuries. (contd.

Figure 12 - Incidence of Wound Caused by Various Wounding Agents.

Contrary to earlier opinions, we believe from our observations that the course of a missile within the body is a straight line in practically every instance. Bizarre or circuitous tracts have been of extreme rarity. The seemingly erratic course of missiles in some cases has almost invariably been explained by accurate consideration of the position of the soldier when struck. (See Figure 13 drawn from a case in this series).

Abdominal Injuries. (contd)

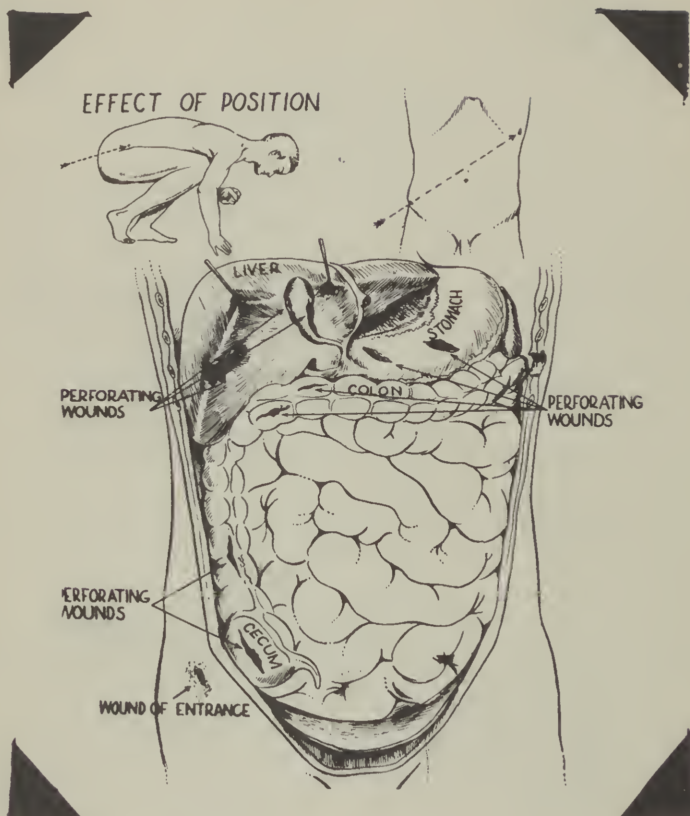

Figure 13 - Effect of Position on Visceral Wounding.

It must be remembered that changes of posture cause significant displacement of viscera from their usual anatomic sites and relationships. We believe that the possibility of other than straight-line tracts has heretofore been greatly over-emphasized. In this series there is no instance of a missile having traversed a major diameter of the abdomen without causing visceral injury.

Artillery shell fragments caused 1844 or 58.5% of the casualties in this series of 3154 cases. (It is probable that many wounds listed in the records as due to shell fragments were actually caused by mortar fire.)

Abdominal Injuries. (contd)

Clinically, the effect of these missiles has been of extraordinary variability. This variability appeared to depend upon the size of the fragment (usually roughly proportional to the caliber of the shell), its shape, and the distance of the soldier from the explosion. The latter has served as a rough index of the velocity of the missile. Explosive, concussive effects upon tissues have been more frequently seen among casualties injured at close range than among those who were at a distance from the shell burst. In general, jagged, lacerated, irregular wounds have been caused more frequently by shell fragments than by small arms missiles, but frequent exceptions have been encountered. Very large fragments or multiple smaller ones emanating from a very near burst have literally removed larger parts of the abdominal parietes, and cases have been observed with the entire flank carried away. Such patients rarely survive even to reach the hospital.

Wounds caused by mortar fragments, especially at short range, are often characterized by a multiplicity of very small fragments, which are of slight mass but high velocity. They apparently decclerate rapidly on impact and penetrate but do not often perforate the body. Patients have been seen literally peppered with tiny holes, with hundreds of small fragments visualized roentgenographically. Each fragment has imparted all of its kinetic energy to the tissues through which it passed, and beneath the cutaneous wounds has been found tissue destruction of almost unbelievable extent. It has been impossible accurately to localize or remove all fragments. The diangosis of abdominal injury has been difficult in the presence of multiple such wounds of the abdominal wall, any number of which may have entered the peritoneal cavity. Laparotomy for exploration and diagnosis has often been indicated.

Rifle bullet wounds have usually been single. Wounds from German machine guns or machine pistols have frequently been multiple because of the very rapid rates of fire of these weapons. The mortality rate of bullet wounds has been 24.7%, slightly greater than that from high explosive fragments, which was 23.1%.

In our experience, the destructive effect upon tissues of small arms missiles has been quite similar to that of high explosive fragments. Striking perpendicularly, bullets often caused clean, small perforations; tangential impact gave rise to large lacerations, and concussive rupture of viscera has been observed. The multiple effects of a bullet were well illustrated in a particular case:

A German prisoner of war had been wounded at about 20 yards range by a 0.30 calibre American carbine bullet. The missile was in the initial phase of high velocity. The wound of entry was in the left mid-axilla, and of exit, through the left pubis. There was a 5 mm. perforation of the diaphragm with very little contusion. The missile caused a gutter wound of the lateral margin of the left kidney, but the concussive effect was such that the entire organ was split widely open to the uretero-pelvic junction. Small, through-and-through perforations of the jejunum were present in two places (perpendicular impact), but

Abdominal Injuries. (contd)

there were extensive mangled perforations and lacerations in the other parts of the bowel (tangential impact). The wound of entry into the bladder was large and explosive in appearance, while that of exit was small and clean.

From the foregoing description, it will be seen that the effects of bullets are multiple, and depend upon velocity as well as upon the angle of impact.

Wounds caused by armor-piercing small caliber bullets have been characterized by the fact that the jacket was usually shed by the projectile and might act as a secondary missile of irregular shape. The steel core caused trauma similar to that from an ordinary lead-core bullet. The jacket has been easily mistaken for a shell fragment in the roentgen film because of its jagged contour. Ricocheted bullets usually were distorted, and frequently the jacket was partially separated at the base. The tearing effect of such missiles upon tissues has been obvious.

Mine fragments have caused a small number of abdominal wounds. Nearly all such injuries have been due to the German "S-Mine" (Bouncing Betty"). The characteristic missiles from these mines have been steel balls (shrapnel) or small, machine-cut steel cylinders. Their effects have been essentially similar to those of shell fragments.

Secondary missiles have consisted of dirt, stones, bone fragments, and rarely bits of the impedimenta present in the soldiers' pockets or of his identification tags. The most important are the bone fragments. In 238 cases in this series, fractures of the pelvis were noted in association with abdominal wounds. In cases in which a missile entered the abdomen through the bony pelvis, there was frequently forcible irruption of spicules of bone into the peritoneal cavity. These bony splinters have been observed to cause perforations of both the large and small intestine, notably the cecum. The same effect has been observed in wounds from missiles entering through the spine.

There have been rare instances of rupture of intraperitoneal viscera associated with wounds which did not penetrate the peritoneum. Such injuries have been caused apparently by missiles of very high velocity and great concussive power.

It must finally be stated that the extent of tissue destruction caused by missiles of war, particularly artillery shell fragments, has at times almost surpassed belief. Intestine has often been shredded to ribbons, and solid viscera have on occasion seemed to have exploded. Completely detached pieces of liver, spleen, or kidney have been observed free in the peritoneal cavity. We have been nothing in civilian surgery which remotely approaches the extent of trauma associated with war wounds.

Abdominal Injuries. (contd)

ENTRY AND EXIT WOUNDS

There have been 2066 penetrating and 656 perforating wounds in this series (data available in 2722 cases). The frequency and mortalities of these types of wounds are represented in Table XIII.

TABLE XIII

Incidence and Mortality, Penetrating and Perforating Abdominal Wounds, 1944 - 1945. (2722 cases data available)

Type of Wound	Number of Cases	Number of Deaths	Percent Mortality
Penetrating	2066	329	15.9%
Perforating	656	155	23.6%
Total	2722	484	17.8%

The anatomical distribution of wounds of entrance into the abdomen is graphically depicted in Figure 14.

In 2586 cases in which data were accurately recorded as to the site of wounds, 1228 (47.5%) missiles entered anteriorly, 730 (28.2%) entered posteriorly, and 617 (23.8%) entered from a lateral aspect of the body. Eleven missiles (0.4%) entered through the perineum. The wounds were nearly identically distributed between the right and left sides of the body. Excluding wounds of the midline, there were 1209 on the right and 1215 on the left. There were 341 or 13% of all wounds in which the entry wound was in the buttocks or region of the hips.

Abdominal Injuries. (contd)

Figure 14 - Distribution of Wounds of Entry.

The most significant discrepancy in the foregoing figures is in the greater incidence of anterior than of posterior wounds. This may possibly be explained by the greater thickness of the musculature of the back and by the presence of the bony spine, both of which would tend to afford more protection than would the anterior abdominal wall. Soldiers with field packs on their backs would also receive added protection, especially against low velocity missiles from behind. Another obvious explanation is that our soldiers were advancing.

Abdominal Injuries. (contd)

TIME LAG

The significance of the interval of time between wounding and surgery is discussed in some detail (Page 132). Because the average time lag between wounding and surgery was relatively short, and in an appreciable numer of cases was less than six hours, many critically wounded cases were admitted who could not have been treated at all, because of impending death, had the first priority surgical hospital been further removed from the lines of battle. The high ratio of these severely wounded who died altered the character of the curve which represented mortality rate plotted against time. The average time lag of all cases plotted against mortality rate yielded a curve with a very gradual slope, but it must be emphatically stated that the duration of the interval between wounding and surgery was of vital significance, and average cases cannot be considered. The several distinct types of casualty must be considered separately. Reference is again made to the section devoted to "Time Lag". (Page 132 .)

PREOPERATIVE CARE AND DIAGNOSIS

The preoperative care of the casualty with an abdominal wound has consisted of the following routine: removal of all clothing; placement of the patient upon a clean litter; rapid but complete physical examination and clinical history, blood typing and cross matching; immediate institution of necessary resuscitation therapy; intramuscular or intravenous administration of penicillin sodium (20,000 - 25,000 units); catheterization if the patient could not void, urinalysis; placement of a Levin tube in the stomach and gastric aspiration, and finally, roentgen examination.

The foregoing measures have been carried out in the main by the shock officer and personnel under his charge. However, it has been the ultimate responsibility of the surgeon who is to operate on a given case to assure himself that all indicated steps in the preoperative care have been performed. Ideally, the surgeon and shock officer jointly cared for the patient, but this has frequently not been possible when the surgeon was operating at the time other cases were received. It is obvious that the history and physical examination, and review of laboratory findings and roentgen films have demanded the personal attention of the surgeon. The surgeon has also decreed the optimum time for operation, although often with the assistance of the shock offiser.

Detailed consideration of the techniques and procedures of resuscitation therapy will be found in the report "Preoperative Preparation" (Page 23). The problems of preoperative diagnosis are dealt with in detail in the discussion of injuries to the various viscera (Part III).

Abdominal Injuries. (contd)

Suffice it to say here that in the average case, diagnosis of wounds of abdominal viscera is inexact, and has been based largely on probability after careful consideration of the site of the entry wound, the site of the exit wound (or of the retained foreign body on the roentgen films or fluoroscopy), the direction from which the soldier believed he was struck, and the posture of the soldier at the moment of wounding. In all cases, the final complete diagnosis could only be made by direct visualization at operation.

PREOPERATIVE CARE AND COMPLICATIONS

Postoperative care and complications are considered in detail in the section on the postoperative care (Page 65) and in Part II of the abdominal section (Page 203). Further discussion is found in Part III of the abdominal section for each specific viscus.

"SHOCK SYNDROME"

An outstanding finding in this study has been that approximately 51% of all deaths occurred within the first 72 hours postoperatively. Battle casualties with abdominal wounds who die in this period fall into a well-defined group of cases. They are nearly always admitted to the hospital in severe shock and respond poorly to resuscitative therapy and to surgery. Preoperatively or postoperatively the blood pressures may be brought to normal levels by massive and rapid transfusions but they cannot be maintained. Severe peritoneal contamination is frequently noted in the records and is clinically believed to contribute materially to the patients' severe illness and poor response to treatment.

We have chosen to designate the symptom-complex described here as the "Shock Syndrome". This term is applied only in abdominal cases in which the clinical picture is as here presented and in which there is a fatal termination.

Before and after operation these patients present the appearances of severe shock. The blood pressure as has been mentioned tends to be low and can be only temporarily sustained by heroic measures. The pulse is weak and rapid. Pulse deficit has been observed. The sensorium may be clouded. The color of the skin is pale, usually with cyanosis or mottling. The temperature is sometimes subnormal and rarely above 100° F. Massive transfusions, careful surgery, constant oxygen inhalational therapy, chemotherapy and all other measures fail appreciably to alter the picture and early deaths ensues. The causes of death commonly cited in these cases are "shock", "irreversible shock", "shock and hemorrhage" or "shock and peritonitis". (By "peritonitis" is usually meant an overwhelming peritoneal contamination.)

Abdominal Injuries. (Shock Syndrome, contd)

It appears that if any significant reduction in the mortality of abdominal wounds below that reported in this series is to be attained, it must come from an increased salvage rate in this group of cases. It is our opinion that relative to the ability of present day surgery to save lives, these casualties represent lethal wounds. The life-saving value of free replacement therapy with whole blood in unquestioned. Nevertheless in patients presenting this shock syndrome it appears to be of no avail. The physiology of severe traumatic shock, particularly in the presence of massive peritoneal insult, must be further understood before these lives can be saved.

ASSOCIATED EXTRA-ABDOMINAL INJURIES

Associated extra-abdominal injuries would be expected to have a pronounced effect upon the mortality of abdominal wounds. This subject is separately considered in Part II. It has been found that contrary to expectations, the mortality rates for patients with and without associated wounds have been nearly the same. Further analysis however has disclosed that there is a constant increase in mortality rates of about 3.8% in the presence of associated injuries, if these rates are plotted against individual groups of cases according to the "multiplicity factor" (i.e., single, double, triple organ injuries, etc.). These data are presented in Figure 26 , Page 154 (report on Associated Injuries in Abdominal Wounds, Part II). It is apparent that the effect of associated injuries in exclusive categories of cases is definite, but that in gross statistics for the series as a whole it is masked by other factors.

THE "MULTIPLICITY FACTOR"

The "multiplicity factor" refers to the number of abdominal organs injured in a given case, as determined at operation. No selectivity of organs is necessarily implied, and combination is limited to numerical incidence alone.

The necessity for determining the extent of injury in abdominal wounds early became apparent in this study. The statistical data that were gathered were often meaningless unless comparable cases could be evaluated. This was particularly true in regard to the time lag and associated injuries, as well as in comparisons of wounds of the given viscus itself.

The most valuable and consistent yardstick for measuring the extent of damage in the abdomen proved to be the number of viscera involved in any given abdominal wound. This "yardstick" we have designated as the "multiplicity factor". As shown in Figure 15. (Mortality rates in percent).

Abdominal Injuries. (The "Multiplicity Factor", contd)

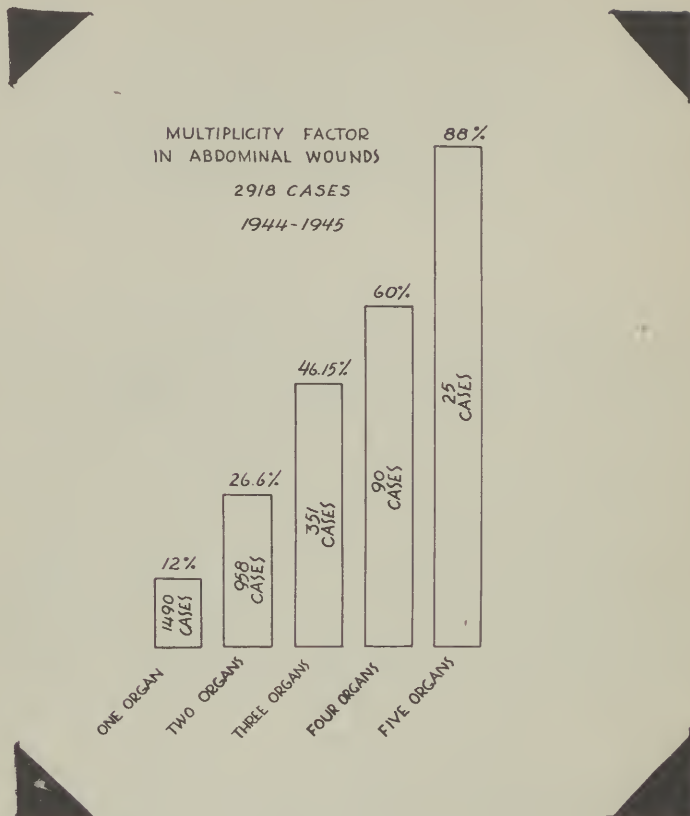

Figure 15 - "Multiplicity Factor" in 2918 Abdominal Wounds.

The mortality rate ascends with each additional organ injured in almost arithmetical progression. Not only does this hold true for abdominal wounds as a whole, but constantly for each particular viscus also.

Abdominal Injuries. contd.

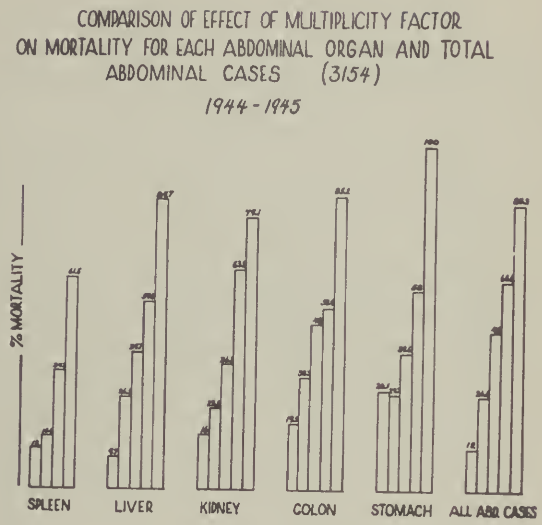

Figure 16 - "Multiplicity Factor" as Applied to Various Viscera.

Variations occurred in a few organs, such as the stomach, pancreas, and in vascular injuries, and in these instances a plausible explanation was apparent for the variation.

It is realized that severe hemorrhage, extensive damage to a single viscus, prolonged time lag, and associated injuries of extra-abdominal structures produce discrepancies which effect the "multiplicity factor" when applied to the individual case, but for group analysis it has proved to be a consistent and valuable index for the assessment of injuries in abdominal wounds.

DISCREPANCIES AND CORRECTIVE FACTORS

The principal numerical discrepancy which arises in subsequent record data is due to the inevitable variation which must occur when different individuals assess records from different points of view. At times the compilation of data was completed for some studies before all the case records were made available. In many instances, the records were incomplete as to particulars sought, and the numerical incidence of cases used was less than the total number of cases in a category. Discrepancies arising in regard to the number of thoraco-abdominal cases recorded in the abdominal section, and the particular section on thoraco-abdominal injuries, are attributable to the fact that the latter study included cases done in 1943 as well as 1944 and 1945, and the definition of thoraco-abdominal cases was more rigid.

From a purely statistical point of view, when cases were omitted from a category because insufficient data were not available for the details sought, variation within a range must be allowed for. This range, applicable to any percentage figure stated, varies with reference to the number of cases with data not recorded, within the limits of most favorable, most unfavorable connotation.

When cases are subdivided into similar groups for purposes of comparison, the usual reservation applies to categories numerically insignificant.

DEATHS

Gross Statistics.

A total of 756 deaths are known to have occurred among the 3154 cases in the forward hospitals in which the initial surgery was performed. This gives an over-all mortality rate of 24%.

As shown in Table IV, page 70 , there was a gradual decrease in mortality rate with increased experience in treating abdominal casualties, the mortality rate of thoraco-abdominal wounds showing the greatest decline. This decline is, we believe, largely the result of better handling of the thoraco-abdominal wounds through the influence of the thoracic surgeons of the Group.

Table XIV, shows the mortality rate for each organ involved.

Abdominal Injuries. (Deaths, contd)

The mortality rates seem much higher than the general overall mortality rate because of the duplication of recorded deaths resulting when multiple organs were injured.

TABLE XIV

Mortality in the Various Viscera Injured (Complicated and Uncomplicated Cases)

Viscous	Cases	Deaths	Mortality
Colon (excluding rectum only wounds)	1106	406	37%
Jejunum and Ileum	1168	345	30%
Liver	829	224	27%
Stomachs	416	169	40%
Kidney	427	149	35%
Spleen	341	85	24%
Rectum	155	47	30%
Bladder	155	46	30%
Duodenum	118	66	56%
Pancreas	62	36	58%
Gall Bladder	53	16	30%
Ureter	27	11	41%

The mortality rate of uncomplicated and complicated injuries of each viscus is given in Table XV:

TABLE XV

Mortality of Uncomplicated and Complicated Wounding of Abdominal Viscera

	Uncomplicated Cases			Complicated Cases*		
Viscous	Cases	Deaths	Mortality	Cases	Deaths	Mortality
Colon (excluding rectum)	251	57	23%	855	387	40.8%
Jejunum and Ileum	353	49	14%	815	296	36.3%
Liver	339	33	10%	490	191	38.2%
Stomach	42	12	28%	374	127	42.0%
Kidney	56	9	16%	371	140	37.7%
Spleen	100	12	12%	241	73	30.3%
Rectum	64	9	14%	91	38	41.7%
Bladder	21	0	0%	134	46	34.4%
Duodenum	2	1	50%	116	65	56.9%

*The mortality rate in complicated cases is apparently high due to the additive effect of the same death being listed under two or more organs.

Abdominal Injuries. (Deaths, Table XV, contd)

Table XV, contd.

Viscus	Uncomplicated Cases Cases	Deaths	Mortality	Complicated Cases* Cases	Deaths	Mortality
Pancreas	1	1	100%	61	35	55.7%
Gall Bladder	0	0	0%	53	16	30.0%
Ureter	1	0	0%	26	11	42.3%

*The mortality rate in complicated cases is apparently high due to the additive effect of the same death being listed under two or more organs.

Day of Death.

Figure 17 below, shows the number of deaths occurring on each postoperative day. Forty-eight percent (363) of all deaths occurred on the day of operation. Of these, four died during the induction of anesthesia, and 83 died during surgery or within 10 minutes thereafter.

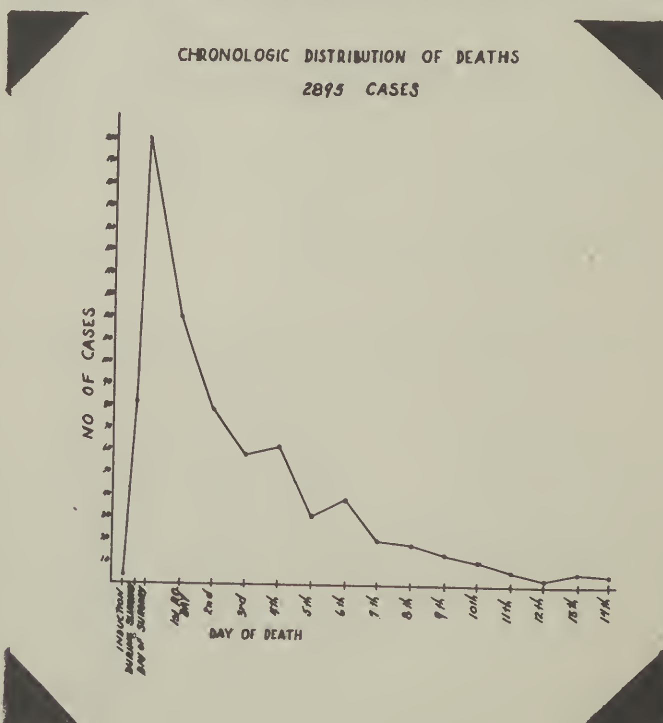

Figure 17- Chronological Distribution of 717 Deaths Occurring in 2895 Cases.

Abdominal Injuries. (Deaths, contd)

The remaining 109 died within 24 hours of the operation. As shown in Figure 19 these deaths, with few exceptions, occurred with the picture of the "shock syndrome".

TABLE XVI

Principal Causes of Death

Cause of Death	Number	Percent of Total Deaths
"Shock"	472	62.4%
Pulmonary	97	12.8%
Peritonitis	91	12.0%
Anuria	35	4.6%
Anaerobic Infection	12	1.6%
Miscellaneous	30	4.0%
No record	19	2.5%
Total	756	99.9%

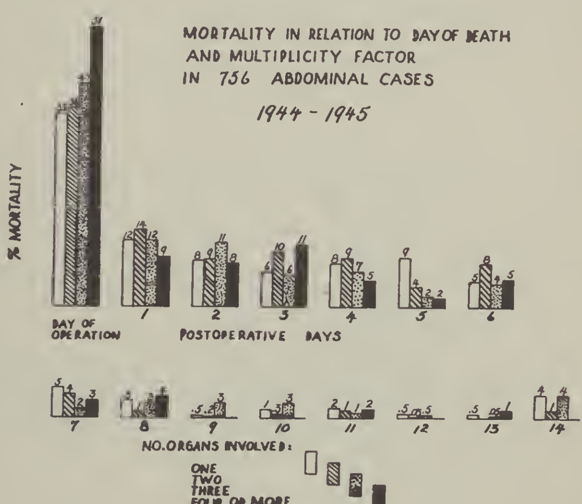

Figure 18 - Mortality in Relation to Day of Death and "Multiplicity Factor".

The multiplicity factor in relation to the day of death is seen in Figure 18 . Since practically all deaths occurring on the day of operation died of shock, it is seen that a higher proportion of patients have this syndomre when a high multiplicity factor is present.

Causes of Death.

Sixty-two percent of patients died in shock within 72 hours of operation. For brevity and clarity, all cases dying with the picture of shock are classified under this heading. Included are 64 cases in which the principal cause of death was acute hemorrhage, cases with shock from severe peritoneal contamination and clinical peritonitis, patients with cardiorespiratory embarrassment, cardiovascular injuries, severe brain injuries, vago-vagal refles, blast injury to the lung, and other relatively rare and shock-producing phenomena.

In approximately 51% of all deaths, no particular shock-producing factor could be singled out as being the principal cause of death. Instead the death seemed to be produced by the interaction of conditions of hemorrhage, peritoneal contamination and tissue destruction, productive of the "shock syndrome" described in Pages 108 - 109 of this section.

Other principal causes of death occurring in a significant number of cases were pulmonary complications, anuria, and peritonitis. These three most significant causes of death, together with the "shock" deaths are graphically illustrated in Figure 19 in relation to the day of death.

It will be noted in Figure 19 that most deaths from pulmonary complications occurred from the second through the seventh postoperative day. These pulmonary complications consisted mainly of pneumonitis, atelectasis, empyema, pulmonary embolism and some balst injury to the lungs, and produced almost 13% of all deaths. They are fully discussed in the report on "Postoperative Complications", pages 205 - 209 and also in the section on "Deaths", page 773

Anuria, if it occurred, was not recognized during World War I as a clinical entity. Deaths from this complication amounted to approximately 5% of total deaths. It is discussed in detail in the report "Posttraumatic Renal Failure", page 758 . .

Abdominal Injuries (Deaths, contd)

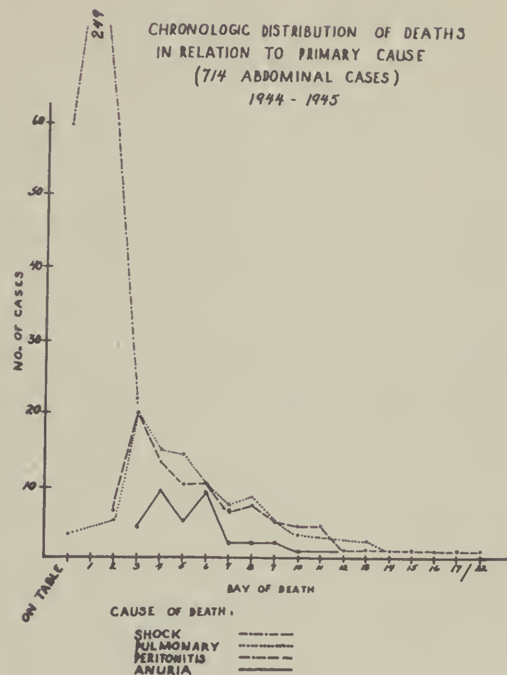

Figure 19 - Principal Causes of Deaths and the Day Deaths Occurred

Peritonitis, as designated here, does not include the early type associated with the "shock syndrome", but refers to the generally recognized clinical type familiar in civilian life. It accounted for 12% of the deaths, death occurring mostly between the second and tenth postoperative days.

Anaerobic infections produced death in 1.5% of all fatal cases. These include anaerobic infections of wounds involving the abdomen or retroperitoneum, as well as extremity anaerobic infections.

Abdominal Injuries. (Deaths, contd)

Approximately 4% of deaths are accounted for by a miscellaneous group of cases, including overlooked visceral lesions, abscesses of the abdomen, dehiscences, intestinal obstructions, and others. The reader is referred to the section on "Deaths in the Forward Hospitals", Pages 773 to 813 for a detailed analysis.

Corrective Factors in Mortality.

The mortality rates as given are admittedly lower than the true figures. It must always be remembered that only deaths occurring in the hospital in which the surgery was initially done are included. No attempt has been made to obtain follow-up data, and no estimates of deaths rates in subsequent installations are available to us.

Moreover, in 256 cases, no record of progress was made after the initial surgery. In 81 cases, no record of subsequent course was available after the third postoperative day. These data were lacking mostly because of movements of teams, or because of very early forced evacuation of patients. By a simple proportion of known deaths occurring in a known number of cases, a corrective factor can be made for the cases with no progress notes. Assuming that the proportion holds true, it is estimated that 67 additional deaths occurred in the initial surgical installations.

This figure raises the gross mortality rate to 26.1%, which figure we believe to be fairly accurate for the deaths occurring in this series. All mortality figures are therefore probably about 2% lower than the true figures for the initial surgical installations.

Discussion of Deaths.

The mortality rate in a series is a composite expression of the interaction in each individual case of all factors which have led to death. By selecting exclusive categories of injuries, we have been able to demonstrate the nature of the major contributing factors. The following facts are pertinent:

1. The original severity of the visceral wound, whether to one organ or to several, is the principal determinant in its lethality. This fact cannot be graphically expressed.

2. The most reliable index of wound severity which is susceptible to statistical study is the multiplicity factor: The more organs injured, the higher the case fatality rate. Multiplicity factor affords a convenient classification of cases into exclusive categories according to severity.

Abdominal Injuries. (Deaths, contd)

3. Prolonged time lag has an adverse influence on prognosis, and the more severe the wound, the greater is the danger from increased time lag.

4. Sixty-two percent of all deaths have occurred within 72 hours of admission to the hospital, and these deaths have almost universally been ascribed to shock.

5. The more severe the shock on admission, the graver the prognosis.

In assaying mortality, two main factors only need be considered, if we except for the moment the less frequent causes of death. First is the original severity of the wound. Our best method of analyzing this is in terms of multiplicity, which is admittedly only an approximation. The second is time lag. The correlating factor between these two is the degree of shock, which is to be regarded as a manifestation of the effects of a wound of given severity affecting the patient for a given length of time. Death ascribed to shock is the extreme manifestation of the combined effects of the two factors.

The following facts have been derived from this study: (a) That there are two categories of cases which show universally high mortality rates. These are cases having high multiplicity factor, and cases admitted to the hospital in severe shock. (b) That cases having high multiplicity have as a group the greatest frequency of severe shock. (c) That cases with high multiplicity are not seen with long time lag. This confirms the logical expectation that the most severely wounded either reach the hospital early or not at all.

Consideration of the facts presented above leads to a conclusion which is quite in agreement with clinical observations. This conclusion is that the majority of deaths (actually about 62%) in forward surgical hospitals occurred among casualties in which theeffects of very severe wounds and of time lag combined to produce a state that could not be corrected. In short, the combined effects of the wound and the time lag are lethal, regardless of all efforts to defeat them.

Pulmonary complications, peritonitis, and renal failure (anuria, "hemoglobinuric nephropathy") have together caused 30% of all deaths. These causes have been shown also to be related at least in part to the severity of the wound and to time lag.

The frequency of pulmonary complications has risen in direct proportion to increase in multiplicity of organ injuries.

Peritonitis has been observed most frequently as a cause of death among patients having unusually prolonged time lag. This would be

expected. The longer peritoneal contamination exists, the greater is the likelihood of development of a virulent peritonitis.

Anuria has usually occurred in patients with initial severe shock, in whom resuscitation has been difficult and who have required massive replacement therapy. These cases seemed closely related to the 62% who died early of the severity of their wounds. The 5% dying in anuria represent similar cases in which early fatality has barely been .verted, but in which fatal physiologic changes were apparently already established.

The remaining 5% of deaths were caused by many miscellaneous factors, including associated wounds, anaerobic infections, and anesthetic and surgical complications. These causes of death cannot be said to have had more than a slight effect upon the mortality rate of the series.

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WOUNDS OF THE ABDOMEN

Part II

Detailed Discussion of Subjects Pertinent to All Abdominal Wounds

THE PROBLEM OF SHOCK THERAPY IN ABDOMINAL WOUNDS

INTRODUCTION

The success of military surgery often depends upon adequate control of shock before and during operation, particularly in forward installations where care is provided for the severely wounded. Of the severely wounded, those with major wounds of the abdomen constitute the greatest problem in the treatment of shock, for the following reasons:

1. Aside from injury to hollow viscera, vascular injury is often extreme either due to isolated laceration of the spleen, liver, or a major vessel. Even more commonly, excessive blood loss arises due to multiple injuries and the laceration of numerous small vessels.

2. The contamination of the peritoneal cavity and/or adjacent retroperitoneal tissue greatly complicates the problem of simple replacement therapy since it imposes the certain threat of overwhelming infection. Intelligent management of this exigency demands that surgical care be instituted with as little delay as possible. Cases with evisceration require prompt surgery for the relief of evisceration and control of peritoneal contamination.

3. The frequent concomitant transdiaphragmatic injury of the thorax is important from the standpoint of cardiopulmonary embarrassment as well as rendering the pleura liable to contamination by bile or bowel contents.

4. The multiple vascular and visceral injuries which are so common in these cases often present surgical problems of great technical difficulty. The duration of anesthesia and operation as well as the blood loss during operation may be extreme.

Intelligent shock therapy plus well-conceived surgery and postoperative care attempts to restore circulatory dynamics to as nearly a normal level as possible. Those in charge of shock therapy as well as the surgeon must always realize the limitations or replacement therapy in patients with continuing hemorrhage or early fulminating infection. In such cases, life may be saved in no other way than by prompt and skilled surgery. The care of these casualties constitutes the greatest challenge to all personnel who work in forward hospitals.

DATA AND REMARKS

During the years 1944 and 1945, 3154 abdominal operations were performed by teams of the 2nd Auxiliary Surgical Group. From this group,

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, contd).

957 cases were taken in which there was perforation of a hollow viscus and in which the data relative to shock therapy were complete. This afforded a means of evaluating shock therapy in which the problem of peritonitis exists. In reviewing the records of all cases it was noted that shock data were more apt to be complete in the poor-risk cases, consequently a relatively high proportion of these cases appears in our series. For this reason our figures on mortality and amount of replacement therapy are somewhat more applicable to the poor-risk than to the average patient.

The classification of shock into statistical categories is difficult since the objectivity and interpretations of different observers may vary considerably. However, for purposes of comparison and reference, the following criteria have been used in the tabulation of the data under discussion.

"Degree" of Shock	Systolic Blood Pressure
Incipient or no shock	101 - 120 plus
Moderate	71 - 100
Severe	41 - 70
Profound or pre-terminal	0 - 40

This classification is employed with the full realization of its shortcomings, chief of which is the fact that the fall in blood pressure does not occur early, and the severity of shock and oligemia are apt to be greater in the first group than the blood pressure indicates. (See "Preoperative Diagnosis and Triage" page 7). However, experience with a large group of severely wounded indicates that once the blood pressure has fallen below normal levels, certain therapeutic and prognostic implications may be deduced from the admission blood pressure readings.

The average time interval is expressed in number of hours from time of injury to initiation of surgery. Among the four groups the average time intervals varied from 10.4 to 11.6 hours (see Table I) and it is evident that these figures are not indicative of the importance of the time factor as related to the degree of shock. Obviously, in wounds of equal severity, the total amount of blood loss and the severity of shock will tend to increase with the passage of time.

TABLE I

957 ABDOMINAL CASES
WITH PERITONEAL CONTAMINATION
SECONDARY TO PERFORATION OF GASTRO-INTESTINAL TRACT

Summary of Replacement Therapy

Admission Systolic Blood Pressure (mm. Mercury)	No. Cases	Incidence Rate	Average Time Interval*	Replacement Therapy**						No. Died	Mortality Rate
				Preoperative		During Surgery					
				Plasma	Blood	Plasma	Blood	Plasma	Blood		
0 - 40	140	14.6%	10.8	713	1745	311	1617	1024	3362	93	66.4%
41 - 70	121	12.7%	10.7	687	1271	311	1278	998	2549	61	50.4%
71 - 100	250	26.1%	11.6	602	873	261	1063	863	2036	95	38.0%
101 - 120	446	46.6%	10.4	492	619	178	962	670	1581	81	18.1%
TOTAL	957	100%	10.7							330	35.4%

* Time, in hours, from injury to operation.

**Blood and plasma, in cubic centimeters, per patient.

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, cont'd).

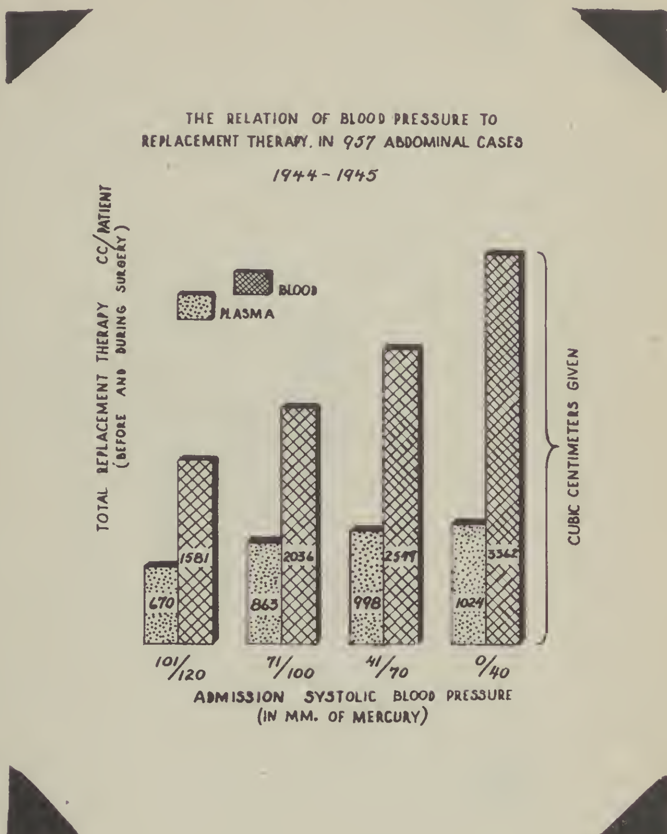

Figure 20 - The Relation of Blood Pressure to Replacement Therapy.

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, contd).

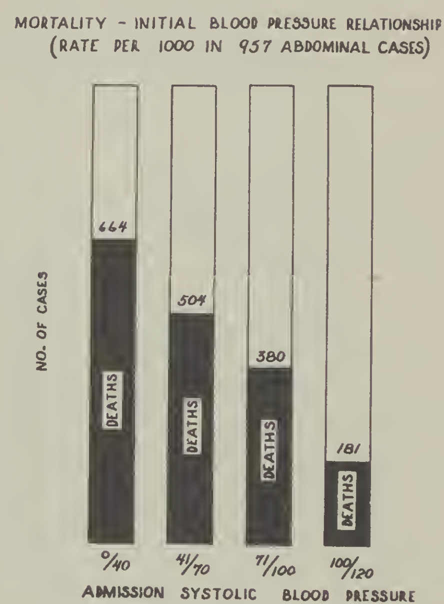

Figure 21 - Mortality - Initial Blood Pressure Relationship.

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, contd).

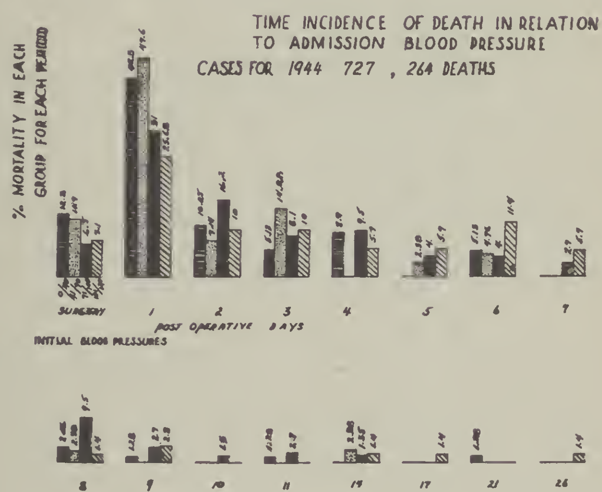

Figure 22 - Day of Death in Relation to Admission Blood Pressure, 1944

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, contd).

Replacement therapy of the war wounded is often actually started in the Battalion Aid Station with the initial unit of reconstituted plasma. Therefore, the figures concerning the quantity of plasma given preoperatively indicate the amount of plasma given prior to admission to the hospital as well as that given in the shock ward. The figures concerning blood and plasma used in replacement therapy are expressed as an average per case in each group. "Total" replacement therapy refers to that amount of blood and plasma which the patient received prior to or during operation.

The mortality rate is expressed separately, in percent, for each group. The vast majority of the deaths occurred in the Field Hospital and it is realized that the death rate would be higher if it were possible to follow each patient through the period of hospitalization in the base section. Table I and Figure 21 show clearly the correlation between the degree of shock and the mortality rate and emphasize the poor prognosis in those cases with severe shock. Figure 22 relates the degree of shock to the time of death and indicates the high incidence of death in the immediate postoperative period.

Further analysis of Table I shows that over 50% of all patients in this series exhibited moderate, severe, or profound shock. The relative amounts of replacement therapy required to accomplish resuscitation increase in almost direct proportion to the degree of shock as shown graphically in Figure 20. As discussed in "The Resuscitation and Preoperative Care of the Severely Wounded" (page 23), this indicates the importance of blood pressure in evaluating the degree of blood loss. However, it must be remembered that the values represent averages for a relatively large number of patients; application of these data to a single patient may lead to error but they represent a general guide to therapy. Furthermore, the volume of replacement therapy which has been found necessary is of the same order of magnitude as the blood loss in various degrees of shock.

The patients in the lowest blood pressure group consistently exhibited more severe injury than those patients whose blood pressure approached normal i.e., multiple visceral injuries were more common in the severe shock groups. Similarly, the incidence of lacerations of the spleen or major vessels was almost four times as common in the 0-40 mm. group as in the 101-120 mm. group. The incidence of these injuries was as follows:

The Problem of Shock Therapy in Abdominal Wounds. (Data and Remarks, contd).

Admission Systolic Blood Pressure (mm. of Mercury)	No. Cases	Spleen or Major Vascular Injury No. Cases	Incidence
0 - 40	140	43	31%
41 - 70	121	25	21%
71 - 100	250	39	16%
101 - 120 +	446	37	8%

These data further emphasize the importance of hemorrhage in the production of severe shock.

THE ROLE OF INFECTION IN PRODUCING SHOCK AND DEATH IN PATIENTS WITH ABDOMINAL INJURIES

The various aspects of fluid loss and changes in the splanchnic vascular bed which follow severe peritoneal contamination have been discussed* and this will not be repeated here. Certainly, fluid loss by seepage from irritated peritoneal surfaces is important in reducing the effective circulating blood volume, though the tendency to hemoconcentration is usually masked by hemorrhage in battle casualties. Also a large volume of relatively static blood may be contained within the dilated splanchnic vascular bed. We believe that these factors suffice in the majority of instances to explain the wound shock which is seen within 6-10 hours after injury. We do not believe, however, that such is a full explanation of the shock which precedes death during the period 24-48 hours after injury. In the latter period shock due to the relatively simple process of blood and plasma loss becomes a more complex phenomenon which depends upon the summation of the deleterious effects of hemorrhage, contamination and beginning infection.

In the final analysis an evaluation of the role of peritonitis in the production of shock becomes essentially a study as to the mechanism of death in peritonitis. Any discussion of either problem is likely to accomplish little because of the paucity of real information concerning the underlying pathological physiology. Too often death from peritonitis is ascribed simply to "toxemia" or the statement is made that "too much contamination was present for the peritoneum to overcome it". What factors

* "Resuscitation and Preoperative Care of the Severely Wounded". (page 23).

The Problem of Shock Therapy in Abdominal Wounds. (The Role of Infection in Producing Shock and Death in Patients With Abdominal Injuries, contd).

are responsible for death in such cases; why did the patient fail to overcome the effects of contamination? These and many more questions must be answered before our understanding of such problems advances beyond the elementary stage.

Certainly, the extent of peritoneal contamination in war wounds is much greater than that ordinarily encountered in civilian surgery. Likewise, the average time (10.7 hours) from injury to operation is considerable and of sufficient duration that the peritonitis of fecal contamination is being supplemented by the peritonitis of bacterial growth. That fatal infection often becomes established is not remarkable in view of previous experiences with the effect of preoperative delay upon the mortality of ruptured duodenal ulcers. The remarkable fact is the predominance of death within 24-48 hours following operation (see Figure 22). Autopsy examination of such patients characteristically shows only moderate dullness and opacity of the peritoneal surfaces; a moderate amount of slightly cloudy serosanguinous exudate and a few strands of fibrinous exudate. Insufficient time (or perhaps shock due to fluid loss) has not allowed the production of a frankly purulent exudate. Or, perhaps, the local leukocytic response is inhibited by the overwhelming nature of the infection similar to that seen in rapidly invasive streptococcal or clostridial infections. The lethal implications of a generalized purulent peritonitis (as seen four to five days after peritoneal contamination) are apparent; it is believed that the peritonitis just described may be of equal significance at an earlier period, particularly in a patient whose recovery from wound shock is incomplete or in progress.

Practically no data are available concerning the bacteriology of the peritonitis which follows severe contamination. Judging from previous experience, little would have been added to our knowledge by such study. However, rare cases of gas infection of the peritoneal cavity have been observed by members of this Group. In one case a pure culture of Cl. welchi was obtained from the peritoneum. (See section on Clostridial Infections, page746).

Obviously much remains to be learned concerning the mechanism of shock in the pathogenesis of infection; the importance of the presence of certain types of organisms (e.g., the Clostridia) or of several symbiotic organisms, etc., are problems for the future.

Perhaps the foregoing preoccupation with the unsolved problems of peritoneal contamination is unwarranted. Certainly, it comprises one of the most difficult problems which have confronted military surgeons during the present war. Experience has shown that severe peritoneal contamination demands prompt surgical care even though, in association

with severe blood loss, it may make resuscitation difficult. In no instance is greater coordination of replacement and surgical therapy required, and preoperative delay must be curtailed as much as possible.

SUMMARY AND CONCLUSIONS

1. From a series of 3154 cases with abdominal injury, shock therapy was analyzed in 957 cases with peritoneal contamination due to perforation of the gastro-intestinal tract.

2. These patients were categorically divided into four groups depending upon their admission blood pressures; the amount of replacement therapy and mortality rates were determined for each group.

3. In this series of abdominal injuries, the necessity for control of shock before and during operation is evident. To accomplish this, blood and plasma were given in quantities which showed a progressive increase as the degree of shock increased.

4. The degree of shock as manifest in the admission blood pressure level, was found to bear a direct relation to mortality which was highest in those cases with excessively low blood pressures. Both factors, i.e., degree of shock and mortality rate, tend to parallel the extent and duration of injury.

5. With increasing degrees of shock there was a progressive rise in the incidence of laceration of a major vessel or of the spleen.

6. The role of infection in the production of shock and death has been discussed briefly. The urgent need for prompt surgery in the control of peritoneal contamination has been stressed.

TIME LAG IN ABDOMINAL INJURIES

That the passage of time has a profound effect upon the wounded soldier is universally accepted. Hemorrhage, peritoneal contamination, and disturbances of physiology are rendered more serious, the longer they remain uncorrected. An index of the severity of these threats to life may be reflected in the wounded men by the degree of shock. Severe shock may be compatible with life for a short time; it is incompatible with life for long.

A review of 3154 traumatic abdominal and thoraco-abdominal cases in reference to time lag is submitted for study. Whenever pertinent data were not available, the fact was indicated in the tables by the reduced number of cases considered, or indicated as not having been recorded.

TIME LAG FROM INJURY TO SURGERY

The average time lag from injury to surgery was 10.1 hours in a series of 2978 cases. Factors which influenced the length of the time interval included terrain, climate, evacuation distance, the tactical situation and the physical capacity of the hospital. The wounded were often recovered from remote and inaccessible positions under enemy fire. Unusual circumstances such as invasions and paratroop landings may have increased the time lag to several days.

The average mortality rate for this series of cases was found to be 22%. (Table I, Appendix).

TIME LAG FROM INJURY TO ADMISSION TO HOSPITAL

The average time lag from injury to admission into the hospital was 6.2 hours for a series of 1107 abdominal cases. (Table II, Appendix).

It was a seeming paradox that the farther forward surgical treatment was initiated, the higher was the overall mortality rate. The reduction of the initial time lag by forward movement of the surgical hospital brought more of the gravely wounded to the operating table. The death rate for the total number of casualties treated, therefore,rose, because in some of the severely wounded the wound was lethal, and the outcome was not affected by treatment. However the mortality rate fell by the initiation of early surgery in those whose wounds were not inevitably fatal, but which would have become so with the passage of time.

TIME LAG FROM HOSPITAL ADMISSION TO SURGERY

The duration of the time interval between admission into the hospital and the commencement of surgery, was the joint decision of the surgeon and the shock officer, provided the available operating room space was

Time Lag in Abdominal Wounds. (Time Lag from Hospital Admission to Surgery.)

not overtaxed by previous cases. The factors which influenced this decision are discussed elsewhere. (Preoperative Diagnosis and Triage, Page 7).

The average time lag from hospital admission to surgery was 3.9 hours in 1157 cases. (Table III, Appendix). Cases operated upon two hours after admission had a mortality rate of 16.1, four hours, a rate of 20.5%, six hours, 33.6% and at 16 hours, 46.4%. The more seriously wounded received the longer shock treatment in many instances, but the futility of delaying surgery beyond an irreducible minimum in those cases suffering from continuing hemorrhage, peritoneal contamination, and significantly altered physiology, may be commented upon.

In Figure 23 plotted on an arithmo-logarithmic scale, the mode of the cases is shown. In Figure 24 the mortality rate of all cases is shown by the heavy line, plotted against eight hour time intervals. The significance of the duration of the interval between wounding and surgery as indicated by the heavy line is masked by several factors. The significance of time lag becomes more apparent when the average is separated into its several components discussed below and shown in Table I and Figure 24.

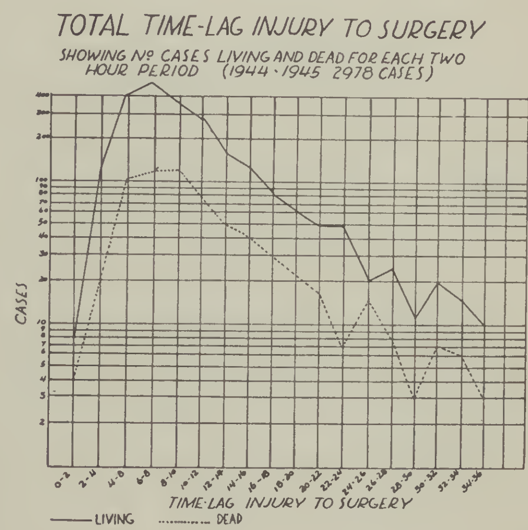

Figure 23 - Number of Cases Living and Dead for Each Two Hour Period.

Time Lag in Abdominal Injuries.

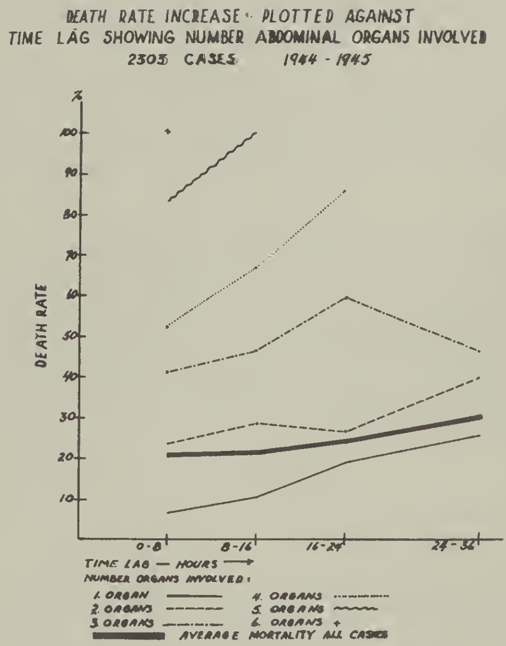

Figure 24 - Death Rate Increase Plotted Against Time Lag Showing Number of Abdominal Organs Involved.

Time Lag in Abdominal Wounds.

TABLE I

Time Lag in Relation to Multiplicity Factor

No. Abdominal Organs Injured.	0 - 8		8 - 16		16 - 24		24 plus	
	Total Cases	Mort. Rate	Total Cases	Mort. Rate	Total Cases	Mort. Rate	Total Cases	Mort. Rate
1	557	6.8%	617	10.6%	142	19.0%	100	25.0%
2	442	23.2%	339	28.3%	91	26.3%	45	40.0%
3	162	41.3%	125	46.4%	22	59.0%	15	46.6%
4	44	52.2%	32	65.6%	7	85.7%	0	
5	18	83.3%	5	100%	0		0	
6	4	100%	0		0		0	

Roughly there are three gradations of the severity of wounded, which differed in their mortality response in respect to time-lag: 1) The most severely wounded in which there was a high mortality rate. In the fatalities in this group, the immediate or impending lethal nature of the wound was not affected by surgery, and the case died within the first two postoperative days. Cases with six abdominal organs appeared only within the first eight hours after wounding; cases with five organs within the first 16 hours; and cases with four organs within the first 24 hours. That the most severely wounded died within the first two days is shown in the section on the "Multiplicity Factor". 2) The second category is that in which the wound itself was potentially lethal, chiefly in reference to the duration of elapsed time. Many of this group were salvaged by early surgery. An example of this group appears in the section on wounds of the small bowel. (Figure 37, Page 254). 3) The third category is small - those lightly wounded, who it might be inferred by the long duration of their time lag, might well have survived without surgery at all. The ratio of cases in these three categories determined the properties of the curve shown.

TABLE II

Comparison of Time Lag, 1944 and 1945

	1944	1945
Total Time - Injury to Surgery	11.3 Hrs.	8.9 Hrs.
Injury to Admission	6.9 Hrs.	5.6 Hrs.
Admission to Surgery	4.5 Hrs.	3.4 Hrs.

Time Lag in Abdominal Wounds.

This comparison doubtless reflected the effects of several factors, which included increased experience, better facilities of transport, type of terrain, and in many instances the desire of the surgeon to commence operation earlier on abdominal injuries.

DISCUSSION

The mortality rate of any unselected group of abdominal cases at any selected time interval from wounding to surgery is approximately constant. This is clearly indicated by the parallelism of the two curves in the arithmo-logarithmic scale of Figure 23 and also by the very gradual rise of the heavy line (average mortality, all cases) in Figure 24. Clinical experience indicates definitely that increasing time lag is highly detrimental to the individual case. Thus a paradoxical situation exists between the overall mortality - time lag relationship and clinical experience. Obviously, a masking effect on the significance of time lag occurs when considering overall averages.

A study of Figure 24 and Table I demonstrates where this masking effect takes place. It is clearly shown that time lag is of marked significance if the severity of the wound is taken into consideration. ("Multiplicity Factor" taken as an index of severity of the wound). It becomes at once apparent that no matter how soon an individual with a high multiplicity range is operated upon, the mortality rate is very high, and the rate increases rapidly with additional hours of time-lag. In fact, if these severely wounded patients are not operated upon early, very few cases will remain alive. This is the group of cases that raises the general overall mortality rate in the short time lag periods (under eight hours).

On the other hand, it is seen that cases with a low "multiplicity factor" have an extremely low mortality rate if operation is carried out early, but with additional hours of delay, a gradual but significant rise in mortality rate is produced. This is the group of cases that raises the mortality rate in the relatively long time lag bracket (over 16 hours).

In effect, therefore, a patient with a low "multiplicity factor" and a long time lag is likely to be in as serious condition as a patient with a higher multiplicity factor and a short time lag.

Thus, a balancing effect takes place between the various multiplicity categories in relation to time lag, so that average overall mortality rates are essentially the same for each selected time interval. In other words, the masking effect noted above takes place unless exclusive categories of the severity of the wounding are taken into account.

It must be borne in mind that mortality rates in relation to time

lag are at best only a rough approximation of the actual picture. No calculation can be accurate unless the absolute number of deaths and the time lag from wounding to death in patients dying before reaching the hospital are known. If these could be determined, and the severity of the wound estimated, the influence of time lag on mortality would be accurately pictured.

SUMMARY AND CONCLUSIONS

1. The interval of time between the wounding and the surgical management of a casualty is of vital significance.

2. Graphs showing the relation of time lag to mortality rate are presented and discussed.

3. Overall averages of mortality rates in relation to time lage are of little significance.

4. The adverse effect of increasing time lag upon mortality is demonstrated by correlating time lag in relation to severity of wounding.

APPENDIX

TABLE I

Total Time Lag - Injury to Surgery - 1944 and 1945

Time - Hours	Lived	Died	Mortality Rate
0 - 2	8	4	33.3%
2 - 4	123	29	18.2%
4 - 6	399	108	19.1%
6 - 8	470	119	17.7%
8 - 10	373	119	19.6%
10 - 12	289	80	20.4%
12 - 14	167	54	25.0%
14 - 16	131	43	22.8
16 - 18	81	30	22.4%
18 - 20	61	23	31.5%
20 - 22	49	17	23.4%
22 - 24	48	7	15.5%
24 - 26	21	15	69.1%
26 - 28	25	8	22.5%
28 - 30	11	3	23.0%
30 - 32	19	7	27.4%
32 - 34	15	6	28.5%
34 - 36	10	3	25.0%
TOTAL	2303	675	22.6% (average)

Average time lag from injury to surgery for the above cases (2978) was 10.1 hours. Under 36 hours, 2303. Thirty six hours and over was 45 and 25.

Under 36 hours	2303	675	22.6%
36 hours and over	45	25	33.3%
Total, all cases	2348	700	22.9% (average)

Average time lag from injury to surgery for all cases including those over the 36 hours was 10.5 hours. (3048 cases).

[illegible]SES NOT INCLUDED: (For discussion purposes)

[illegible] available - 119.

Appendix. (contd.)

TABLE II

Injury to Admission 1944 - 1945

Hours	Lived	Dead	Mortality Rate
0 - 2	54	17	21.4%
2 - 4	262	86	22.9%
4 - 6	239	66	19.3%
6 - 8	120	26	16.9%
8 - 10	61	19	21.5%
10 - 12	31	14	26.6%
12 - 14	19	11	49.9%
14 - 16	15	6	33.3%
16 - 18	16	2	13.3%
18 - 20	9	1	10.1%
20 - 22	7	3	37.5%
22 - 24	7	2	25.0%
24 - 26	4	1	20.0%
26 - 28	2	1	33.3%
28 - 30	4	3	45.0%
30 - 32	3	3	50.0%
32 - 34	2	0	00.0%
34 - 36	1	1	50.0%
TOTAL	846	261	23.5% (av.)

Average "time lag" for the above cases (1107) was 6.2 hours.

Under 36 hours -	846	261	23.5%
36 hours and over -	0	7	100.0%
Total All Cases	846	268	24.0%

Average "time lag" from injury to admission for all cases (1114) including those over 36 hours was 6.5 hours.

NOTE: The above table is based on 1114 cases only. Either "time of injury" or "admission to hospital" time was lacking on all the others making it impossible to determine the time lag.

Appendix. (contd)

TABLE III

Time Lag - Admission to Surgery 1944 - 1945

Hours	Lived	Dead	Mortality Rate
0 - 2	156	30	16.1%
2 - 4	405	105	20.5%
4 - 6	174	88	33.6%
6 - 8	85	35	29.1%
8 - 10	32	16	33.3%
10 - 12	17	6	27.5%
12 @ 14	7	1	14.2%
14 - 16	5	4	46.4%
16 - 18	2	0	00.0%
18 - 20	1	0	00.0%
20 - 22	0	0	00.0%
22 - 24	1	0	00.0%
24 - 26	0	2	100.0%
26 - 28	0	0	00.0%
28 - 30	0	0	00.0%
30 - 32	0	0	00.0%
32 - 34	0	0	00.0%
34 - 36	0	0	00.0%
TOTAL	883	274	23.6% (av.)

The average "time lag" from admission into the hospital until surgery for the above cases (1157) was 3.9 hours.

Under 36 hours -	883	274	23.6%
36 hours and over -	0	1	100.0%
Total All Cases -	883	275	23.7% Average

The average "time lag" from admission to surgery remained the same when the one over 36 hours was added, namely 3.9 hours.

NOTE: The above tabulization was made from a series of 1158 cases, the remainder of the abdominal series lacking sufficient data to determine accurate time lag.

Appendix. contd.

TABLE IV

Total Time Lag - Injury to Surgery 1944

Hours	Lived	Dead	Mortality Rate
0 - 2	2	4	66.6%
2 - 4	75	19	20.2%
4 - 6	278	79	22.1%
6 - 8	337	99	22.4%
8 - 10	288	92	24.2%
10 - 12	221	65	22.8%
12 - 14	125	39	23.7%
14 - 16	107	37	25.7%
16 - 18	71	28	28.2%
18 - 20	50	23	31.5%
20 - 22	41	15	26.8%
22 - 24	38	7	15.5%
24 - 26	21	13	38.2%
26 - 28	21	7	25.0%
28 - 30	10	3	23.0%
30 - 32	14	5	26.3%
32 - 34	15	6	28.5%
34 - 36	9	3	25.0%
TOTAL	1723	544	23.5% (av.)

Average "time lag" from injury to surgery for all cases including those over 36 hours, was 11.4 hours.

Average "Time"lag" from injury to surgery for the above cases (2088) was 11.3 hours.

Under 36 hours -	1723	544	23.5%
36 hours and over -	36	18	33.3%
Total All Cases -	1759	562	24.2% (av.)

Cases not included (for discussion purposes)

No record available - 119.

Appendix. (contd)

TABLE V

Time Lag Injury to Admission - 1944

Hours	Lived	Dead	Mortality Rate
0- 2	34	13	27.7%
2 - 4	173	64	26.8%
4 - 6	151	53	25.9%
6 - 8	80	19	19.2%
8 - 10	39	15	27.7%
10 - 12	18	12	40.0%
12 - 14	18	9	33.3%
14 - 16	12	6	33.3%
16 - 18	13	2	13.3%
18 - 20	9	1	10.0%
20 - 22	5	3	37.5%
22 - 24	6	2	25.0%
24 - 26	4	1	20.0%
26 - 28	2	1	33.3%
28 - 30	3	2	40.0%
30 - 32	3	3	50.0%
32 - 34	2	0	00.0%
34 - 36	1	1	50.0%
Under 36 hours	573	208	23.6% (av.)
36 hours and over	0	2	100.0%
Total All Cases	573	210	23.7%

Average "time lag" for all cases (783) from injury to admission to hospital was 6.9 hours.

NOTE: The above table is based on only 783 cases, all other cases of the abdominal series lacked sufficient data to determine "time lag".

Appendix. (Contd)

TABLE VI

Time Lag - Admission to Surgery - 1944

Hours	Lived	Dead	Percent Mortality
0 - 2	66	20	23.2%
2 - 4	269	78	22.4%
4 - 6	132	61	31.6%
6 - 8	66	31	33.0%
8 - 10	27	13	32.5%
10 - 12	12	3	20.0%
12 - 14	6	0	00.0%
14 - 16	4	3	42.8%
16 - 18	1	0	00.0%
18 - 20	1	0	00.0%
20 - 22	0	0	00.0%
22 - 24	1	0	00.0%
24 - 26	0	2	100.0%
26 - 28			
28 - 30			
30 - 32			
32 - 34			
34 - 36			
TOTAL	585	211	26.5% (av)

The average "time lag" for the above cases (769) was 4.5 hours.

Under 36 hours	- 585	211	26.5%
36 hours and over	- 0	1	100.0%
Total all Cases	585	212	26.5% (av.)

The average "time lag" after including the one case over 36 hours, remained 4.5 hours.

NOTE: The above tabulation was made from a series of 797 cases; the remainder of the cases of the abdominal series had insufficient data to accurately determine the time lag.

Appendix. (contd).

TABLE VII

Injury to Surgery - Total Time Lag 1945

Hours	Lived	Dead	Mortality Rate
0 - 2	6	0	00.0%
2 - 4	51	10	16.3%
4 - 6	121	29	16.1%
6 - 8	133	20	13.0%
8 - 10	85	27	15.1%
10 - 12	68	15	18.0%
12 - 14	42	15	26.3%
14 - 16	24	6	20.0%
16 - 18	10	2	16.6%
18 - 20	11	0	00.0%
20 - 22	8	2	20.0%
22 - 24	1	0	00.0%
24 - 26	0	2	100.0%
26 - 28	4	1	20.0%
28 - 30	1	0	00.0%
30 - 32	5	2	28.5%
32 - 34	0	0	00.0%
34 - 36	1	0	00.0%
TOTAL	580	131	18.4%

Average "time lag" from injury to surgery for the above cases (711) was 8.9 hours.

Under 36 hours	-	580	131	18.4%
36 hours and over	-	9	7	43.7%
Total All Cases		589	138	18.8%

Average "time lag" from injury to surgery for all cases including those over 36 hours was 9.7 hours.

Cases not included (for discussion purposes)

No record available - 43.

Appendix. (contd)

TABLE VIII

Time Lag - Injury to Admission - 1945

Hours	Lived	Dead	Mortality Rate
0 - 2	20	4	15.1%
2 - 4	89	21	19.0%
4 - 6	88	13	12.8%
6 - 8	40	7	14.7%
8 - 10	22	4	15.3%
10 - 12	13	2	13.3%
12 - 14	1	2	66.6%
14 - 16	3	0	00.0%
16 - 18	3	0	00.0%
18 - 20	0	0	00.0%
20 - 22	2	0	00.0%
22 - 24	1	0	00.0%
24 - 26	0	0	00.0%
26 - 28	0	0	00.0%
28 - 30	1	1	50.0%
30 - 32	0	0	00.0%
32 - 34	0	0	00.0%
34 - 36	0	0	00.0%
TOTAL	273	53	16.0%

Average "time lag" for all cases from injury to admission for the above cases (326) was 5.6 hours.

Under 36 hours	-	273	53	16.0%
36 hours and over	-	0	5	100.0%
Total All Cases	-	273	58	17.5%

Average "time lag" for all cases (331) including those over 36 hours was 6.1 hours.

NOTE: The above table is based on only 331 cases, all other cases of the abdominal series lacked sufficient data to determine time lag.

Appendix. (contd.

TABLE IX

Time Lag - Admission to Surgery - 1945

Hours	Lived	Dead	Mortality Rate
2 - 4	88	10	10.2%
4 - 6	136	27	16.5%
6 - 8	42	14	25.0%
6 - 8	19	4	17.3%
8 - 10	5	3	35.0%
10 - 12	5	3	35.0%
12 - 14	1	1	50.0%
14 - 16	1	1	50.0%
16 - 18	1	0	00.0%
18 - 20			
20 - 22			
22 - 24			
24 - 26			
26 - 28			
28 - 30			
30 - 32			
32 - 34			
34 - 36			
TOTAL	298	63	17.4% (av.)

The average "time lag" from admission to surgery for the above cases (361) was 3.4 hours.

36 hours and over - none.

NOTE: The above tabulation was made from a total of 361 cases; many cases not included because time of admission into the hospital was not mentioned, thus making it impossible to compute time lag.

INCIDENCE OF ASSOCIATED INJURIES AND THEIR EFFECT ON MORTALITY IN ABDOMINAL CASES

During the year of 1944 and early months of 1945, the surgical teams of this Group operated on 3154 patients with abdominal injuries. Of this total, there were 839 thoraco-abdominal wounds and 1089 cases which presented various major extra-abdominal associated injuries other than the thoraco-abdominal type. It is the latter group that is reported in this paper.* The records of the 1089 cases have been reviewed and analyzed in an attempt to determine the incidence of various type of associated injuries and their effect upon the general mortality.

Surgical shock and time lag as accompanying and potential influences on mortality will be considered briefly. It is probably well to point out before presenting the detailed analysis of the cases, that the general overall mortality rates were found to be closely similar in three large groups of cases, viz:

A. All abdominal cases - 23.1% (2315 cases), (Exclusive of thoraco-abdominal injuries)

B. Abdominal cases with associated injuries - 24.1% (1089 cases).

C. Abdominal cases without associated injuries - 22.1% (1226 cases).

This near agreement of figures is remarkable and at a glance, likely to be surprising. Nevertheless, it constitutes one of our findings and we believe it represents a significant truth. Our interpretation of this finding may be stated as follows: Of associated injuries it is likely that many of the more severe and rapidly fatal ones are screened from surgery by an early death, leaving the less severe ones to reach the hospital and to influence the mortality. Also, there seems to be a tendency towards coupling severe abdominal injuries with less severe associated injuries and vice versa. Working together, such factors as these would obviously tend to balance the general mortality rates for the two groups designated "B" and "C" above.

CLASSIFICATION OF INJURIES

Occurring concomitantly with abdominal injuries, there are innumerable types of associated wounds. In view of their frequent multiplicity and complexity, a thorough-going classification would almost call for individual consideration of cases.

* The cases which presented thoraco-abdominal injuries were excluded from this study and are analyzed in a separate section of this report.

Incidence of Associated Injuries and their Effect on Mortality in Abdominal Cases (Calssification of Injuries, contd)

In this study we have excluded the obviously minor injuries of all regions. We have endeavored to consider only the major associated injuries, i.e., those of sufficient severity and magnitude to influence the prognosis during surgery and the early postoperative period.

In an attempt to appropriately classify the cases and injuries we have been led to the belief that no single basis for analysis will serve for all purposes. Desiring to establish the incidence of the various associated injuries, we adopted for this purpose a dual classification. Its nature is self-evident in the tables. Tables I-A and I-B show the incidence of associated injuries as to their anatomic types, and tables I, II, and III (Appendix), show their incidence as to their multiplicity. The number of deaths and mortality rates for specific types and groups are also shown in the tables.

Probably the most significant information depicted in Tables I, II, and III (Appendix), is that of frequency. The mortality figures are interesting, but it is to be remembered that the deaths in many cases were probably not due to the associated injury per se, but to one or more of several factors in play. The bulk of evidence produced in this study has indicated that the one quality of associated injuries that is most significantly related to their effect on mortality is the "severity"* and not their type nor their degree of multiplicity.

For this reason, in our analysis of the fatal cases we were prompted to utilize a third classification of the associated injuries, viz., that based on the "severity", all cases being classed "moderate" or "severe". The findings relative to this analysis are shown in the graphic figures 25 , 26 and 27 .

INCIDENCE OF ASSOCIATED INJURIES

Excluding the thoraco-abdominal wounds, there were 2315 abdominal cases operated on. Of these, 1089 or 47%** presented associated injuries.

* It has been shown in other studies that with reference to abdominal injuries, the "multiplicity of organs involved" is the paramount feature influencing mortality. (See page 109 .)

** If thoracic injury in thoraco-abdominal cases had been considered as an associated injury, the incidence would have been 61.1%.

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Incidence of Associated Injuries, contd)

Definition and Incidence of Anatomic Types:

All major associated injuries were "broken down" into nine fundamental types:

1. Soft tissue -- (All except those coincident to other types*)
2. Fractures -- (All fractures of major long bones and bones of the pelvis)
3. Chest injuries -- (All those involving the pleura and requiring surgery exclusive of thoraco-abdominal wounds)
4. Spinal cord injuries -- (All injuries to the spinal cord and cauda equina)
5. Brain injuries -- (All types)
6. Maxillofacial and/or neck injuries -- (Major)
7. Major vessel injuries -- (All extra-abdominal)
8. Peripheral nerve injuries
9. Injuries necessitating major amputations

There were 1551 injuries encountered among 1089 cases. Of the 1551, 1403** were analyzed as to incidence and are shown in Table I-A.

TABLE I-A

Frequency of Occurrence of 1403 Associated Injuries According to Anatomic Types

Type of Injury	No. of Injuries Encountered	Percent of Total Injuries	
Fractures	659	47.0%)	
Soft tissue	531	37.8%)	91.9%
Chest	101	7.1%)	
Spinal cord	40	2.9%)	
Maxillofacial and/or neck	20	1.4%)	
Major vessel	18	1.2%)	7.8%
Peripheral nerve	10	0.7%)	
Wound necessitating major amputation	18	1.2%)	
Brain	6	0.4%)	
Total	1403	99.2%	

* Fractures, nerve injuries, and injuries necessitating amputations all present coincident soft tissue injuries. Such soft tissue injuries were not counted separately.

** Number of injuries in which data in the records were adequate for this study.

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Incidence of Associated Injuries, contd)

TABLE I-B

Incidence of Fractures of Femur, Humerus and Pelvis

Bone Involved	No. Cases	No. Deaths
Femur alone	57	13
Femur and one other major bone	33	10
Humerus alone	31	10
Humerus and one other major bone	21	5
Pelvic bones	238	52
Total	380	90

GENERAL INCIDENCE OF ASSOCIATED INJURIES

TABLE II

Grouping and Incidence of Associated Injuries According to Their Multiplicity

Group	No. Cases	Mortality	Percent of Total Cases
Cases presenting one associated injury	527	20.7%	75.8%
Cases presenting two associated injuries	299	21.3%	
Cases presenting three associated injuries	142	39.0%	24.2%
Cases presenting four or more associated injuries	124	23.3%	

A more detailed analysis of the cases comprising the above categories is shown in Tables I, II and III (Appendix).

It will be noted from Table II that in all except one group of cases (those presenting three associated injuries), the group mortality rates were relatively close to and slightly less than that for all abdominal cases. Since in the classification neither the severity of associated injury nor the nature of the abdominal injury is taken into consideration, the mortality rates for groups one, two and four* are within the limits of what we would expect. The mortality rate of 39% for group three, however, warrants further consideration and analysis. Even though the cases comprising group three probably presented more severe injuries than did those of any other group, it is unlikely that the associated injuries accounted for the uniquely high mortality rate. We were led to this belief when we re-analyzed, on the basis of other factors, 25 fatal and 25 nonfatal cases of group three. The findings relative to the 50 cases re-analyzed are shown in Tables IV and V (Appendix). It is to be noted that among the fatal cases such factors as prolonged time

* Cases comprising group four were not the most severe injuries. Multiplicity rather than severity was the dominant feature among them.

lag, severe degrees of shock and multiplicity of visceral injuries were much in evidence, whereas among the nonfatal cases they were conspicuously low or present in less grave combinations.

Shock and Time Lag

The number of patients who were in each of the various degrees of shock are presented in tabular form (Table III). No effort has been made to analyze the specific causes of shock. (See section of this report on "Shock", page108.) We have regarded shock for the purposes of this report as a clinical manifestation of the combined effects of the severity of the patient's injuries and the length of time lag. It will be seen from Table III that nearly 60% of the cases in this series were in either "moderate" or "severe" shock. In arriving at our classification, all available data in the records were utilized (e.g., the surgeon's estimate of the degree of shock, the recorded blood pressure readings, etc.).

TABLE III

Degree of Shock, 1089 Abdominal Cases Having Major Associated Injuries

Grade of Shock	No. Cases	Percent of Total Cases
No shock or suspected shock	184	16.8%
Mild shock	270	24.8%
Moderate shock	292	26.8%
Severe shock	343	31.5%
Total	1089	99.9%

Time lag appears to bear no uniform relationship to the general mortality. In the great majority of cases time lags fall within rather narrow limits* (six to 12 hours). In our group, the largest number of deaths occurred in patients with time lags of six to 10 hours. (See Table IV.)

MORTALITY

Among the 1089 cases, there were 262 deaths. An accurate appraisal of these deaths as to cause is difficult on survey of the records. Because of the usual complexity of the injuries, we cannot rightfully condemn one injury and exonerate another. It is likely that in most instances

* See section of this report on "Time Lag" (Page 132).

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Mortality, contd)

the deaths resulted from an unpredictable interplay of several factors, each known to be capable of influencing the mortality. In attempting to evaluate any one of these factors, exclusion of the others would be desirable but this is rarely, if ever, completely possible.

TABLE IV

Length of Time Lag, Wounding to Surgery, 262 Fatal Abdominal Cases Having Major Associated Injuries

Time Lag (Injury to Surgery)	No. Cases	Frequency among Total Deaths
0 to 5 hours	34	13.0%
6 to 10 hours	110	42.0%
11 to 15 hours	53	20.2%
More than 15 hours	47	17.9%
Not recorded	18	6.9%
Total	262	100.0%

The question of what effect associated injuries have on the mortality rate in abdominal cases has proved to be an intriguing subject for study. Our method of attack on the problem was to analyze the mortality in three rather large groups of cases. These groups were:

1. All abdominal cases (both with and without associated injuries -- 3154 cases).

2. Abdominal cases <u>without</u> associated injuries (1226 cases).

3. Abdominal cases <u>with</u> associated injuries (1089 cases).

Each of these groups was analyzed with respect to multiplicity of abdominal visceral injuries, and the third group the severity of the associated injury is taken into consideration.

The results of this analysis are represented in condensed form in Figures 25 , 26 and 27 *. On examining Figure 25 it will be seen that the overall mortality rate in abdominal cases starts at 5% and ascends uniformly to 65%**. The rates in this group, when represented as a curve, serve as a fair average for comparison. (See curve "a" in

* Tables VI and VII (Appendix) show the numerical basis for the graphs.

** Figures taken from the section on Abdominal Injuries.

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Mortality, contd)

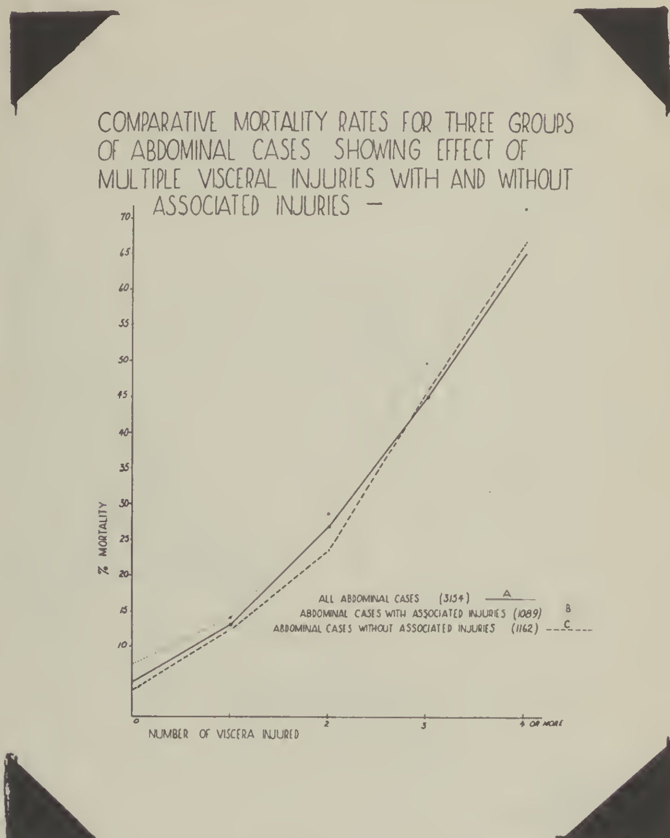

Figure 25 - Comparative Mortality Rates Among Abdominal Cases With and Without Associated Injuries.

Figure 25). The effect of the presence or absence of associated injuries on mortality is apparent in the corresponding curves for the other two groups (See curves "b" and "c", Figure 25). It is seen that they are roughly parallel and separated by an average difference of only 3.8% and that they follow quite closely the "overall" curve throughout.

The incidence and distribution of "moderate" and "severe" associated injuries are plotted against multiplicity of visceral injury in fatal cases. (See Figure 27) The contours of the two curves, when correlated with the multiplicity of visceral injury serve two significant purposes, viz:

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Mortality, contd)

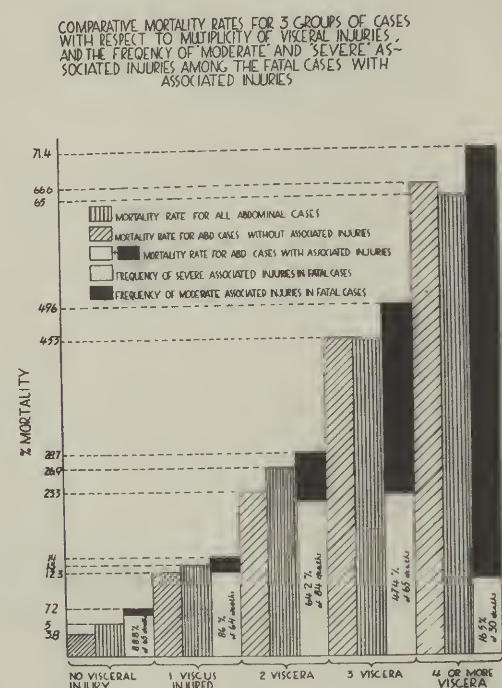

Figure 26 - Comparative Mortality Rates Among Abdominal Cases With and Without Associated Injuries

1. They indicate the type (or severity) of associated injuries that reach the surgeon and the type of abdominal injury with which they are most frequently associated.

2. They tend to explain why in those cases reaching the surgeon associated injuries do not elevate the mortality rate more.

In essence, the salient implications are these:

Patients sustaining both severe abdominal and severe associated injuries evidently do not live to reach the surgeon. Associated injuries in general, regardless of the multiplicity of the visceral

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Mortality, contd)

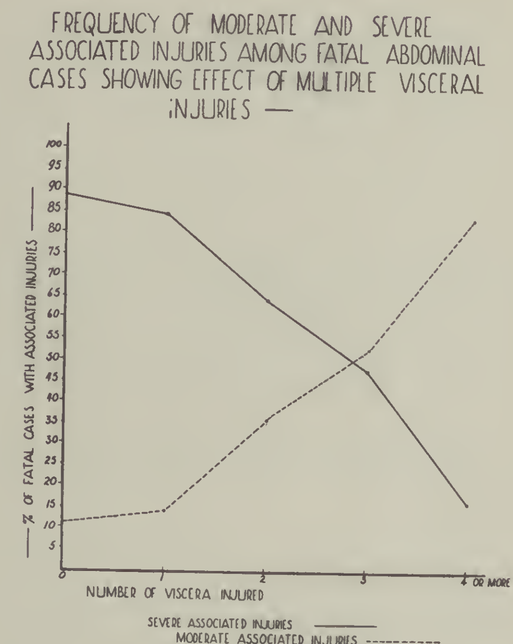

Figure 27 - Incidence of Severe and Nonsevere Associated Injuries Among Serious and Less Serious Abdominal Injuries.

injury, tend to increase the mortality rate by about 3.8% over that of cases without associated injuries. This increase is contributed to by associated injuries of all degrees of severity, but relatively mild associated injuries are predominant with the more multiple abdominal injuries, and severe associated injuries predominate with the less multiple abdominal injuries. Of all factors influencing mortality, that of multiplicity of visceral injury seems to be paramount and most constant, increasing mortality rate by approximately 15% with each additional viscus injured.

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Mortality, contd)

In the section of this report devoted to the small bowel, a group of cases with uncomplicated small bowel injuries were analyzed. The incidence of severe associated injuries was found to be 55% in 49 fatal cases and 24% in 304 survival cases. From this doubly high incidence in the fatal cases one might suspect associated injuries of influencing the mortality rate more than is indicated in this study. It is noteworthy however, that the time lags in the fatal cases were found suspiciously long, with an average double that in the survival cases.

SUMMARY

1. The records of 1089 cases, receiving abdominal operations and presenting extra-abdominal associated injuries, were reviewed and the results of the study are presented.

2. The incidence of associated injuries was studied and the following information is shown in accompanying tables and graphs:

a. Incidence among the grand total of abdominal cases (3154).
b. Incidence (anatomic) among the total number of associated injuries (1403).
c. Incidence, on the basis of multiplicity of associated injuries.

3. Mortality among cases with associated injuries was compared to that in cases without associated injuries. The elevating effect of associated injuries on the general mortality rate was determined and is illustrated graphically.

4. The probable factors accounting for this effect are discussed.

OBSERVATIONS

1. Associated injuries were present in 47% of cases receiving abdominal operations, if thoraco-abdominal injuries are excluded, and in 61.1% if they are included as associated injuries.

2. There were 1551 associated injuries in 1089 abdominal cases. In 1403 of 1551 associated injuries, records were satisfactory, and the following anatomic type incidence was found:

Fractures	47.0%	
Soft tissue	37.8%	. . . 91.9%
Chest	7.1%	
All others (6 types)		7.8%

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Observation, contd)

3. The general mortality in the group with associated injuries is found to approximate closely that for the group without such injuries.

4. When, however, the cases are classified according to multiplicity of visceral injury, the group of cases having associated injuries was found to have a mortality rate approximately 3.8% higher than that for the group without.

5. Associated injuries were classified according to severity as "moderate" and "severe". The severe ones were found to be predominantly coupled with the abdominal injuries of low multiplicity and the moderate ones with abdominal injuries of high multiplicity..

6. Mortality in the group of cases with associated injuries as well as in that without was found to increase appreciably with each additional visceral injury.

CONCLUSIONS

1. The case incidence of associated injuries among abdominal battle casualties was of the order of 50% (when thoraco-abdominal injuries are excluded).

2. Of the major associated injuries encountered, fractures, soft tissue wounds, and chest wounds constituted the majority (in our series 91.9%). Six other types, viz., spinal cord, maxillofacial and/or neck, peripheral nerve, major vessels, brain injuries, and injuries necessitating amputations made up the minority of 8 - 10%.

3. Fractures proved to be the most common of all major associated injuries and of the fractures, those of pelvic bones were encountered most frequently.

4. Major associated injuries influence the abdominal mortality rate, increasing it by approximately 3.8%. This influence appears to be fairly constant regardless of the multiplicity of visceral injury.

5. Its constancy and relatively small magnitude are probably explainable by the following reasoning: Few patients reach the surgeon with both the more serious abdominal and associated injuries. With the more serious abdominal injuries are found the less serious associated injuries; and conversely, the more serious associated injuries are found in the presence of less severe abdominal wounds.

Incidence of Associated Injuries and Their Effect on Mortality in Abdomina Cases (contd)

APPENDIX

TABLE I

Incidence and Mortality in Cases with One Associated Injury

	No. Cases	Deaths	Mortality
Soft tissue	182	37	20.3%
Fracture	236	40	17.0%
Chest	42	14	33.3%
Spinal cord	28	14	50.0%
Brain	6	2	33.3%
Maxillofacial / Neck	13	3	23.0%
Major vessel	5	2	40.0%
Peripheral nerve	6	0	0;0%
Injuries necessitating amputations	9	3	33.3%
Totals	527	115	20.7%

TABLE II

Incidence and Mortality in Cases with Two Associated Injuries.

	No. Cases	Deaths	Mortality
Fracture and soft tissue	72	13	18.0%
Double fracture	92	21	22.8%
Double soft tissue	37	8	21.6%
Soft tissue and chest	14	2	14.2%
Fracture and chest	19	5	26.3%
Fracture and major vessel	5	1	20.0%
Fracture and spinal cord	5	2	40.0%
Soft tissue and spinal cord	6	1	16.6%
Soft tissue and vessel	8	1	12.5%
Fracture and amputation	6	0	0.0%
Other combinations (rare)	35	10	28.8%
Totals	299	64	21.3%

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Appendix, contd)

TABLE III

Incidence and Mortality in Cases with Three Associated Injuries

	No. Cases	Deaths	Mortality
Triple Fracture	10	1	10.0%
Triple soft tissue	15	9	60.0%
Fracture and double soft tissue	54	13	24.0%
Soft tissue, fracture and chest	8	7	87.0%
Double fracture and chest	14	9	64.3%
Soft tissue, fracture and cord	1	0	0.0%
Double soft tissue and amputation	3	1	33.3%
Soft tissue, fracture and peripheral nerve	4	1	25.0%
Soft tissue, fracture and maxillofacial	3	1	33.3%
Chest, fracture and maxillofacial	4	2	50.0%
Other rare combinations	26	12	46.1%
Totals	142	56	39.0%

Incidence and Mortality in Cases Presenting Four or More Associated Injuries.

Total cases in this group 121
Number of deaths 27
Group mortality 23.3%

(Specific types not tabulated because of extreme multiplicity in this group.)

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Appendix, contd)

TABLE IV

Analysis of 25 Nonfatal Cases Having Three Associated Injuries with Reference to Presence of Other Factors Possibly Influencing Mortality

	Time Lag in Hours	Degree of Shock	No. of Abdominal Viscera Involved
1.	5	Mild	1
2.	5½	Moderate	1
3.	4½	Severe	2
4.	5	Mild	1
5.	23	Moderate	1
6.	22	Mild	1
7.	23	Mild	1
8.	21	Mild	2
9.	22	Mild	1
10.	14	Mild	1
11.	11	Mild	1
12.	12	Mild	1
13.	16	Mild	2
14.	12	Mild	2
15.	14	Mild	1
16.	15	Severe	2
17.	14	Moderate	3
18.	9	Mild	2
19.	8	Moderate	1
20.	8	Mild	1
21.	6	Mild	1
22.	10	Mild	1
23.	7	Mild	1
24.	7	Moderate	1
25.	6	Moderate	2

Incidence of Associated Injuries and Their Effect on Mortality in Abdominal Cases (Appendix, contd)

TABLE V

Analysis of 25 Fatal Cases Having Three Associated Injuries with Reference to Presence of Other Factors Possibly Influencing Mortality

	Time Lag in Hours	Degree of Shock	No. of Abdominal Viscera Involved
1.	11½	Mild	2
2.	6	Severe	4
3.	13	Severe	1
4.	10	Severe	3
5.	12	Moderate	1
6.	11½	Severe	2
7.	17	Severe	2
8.	8½	Moderate	1
9.	24	Severe	1
10.	18	Severe	1
11.	14	Moderate	1
12.	15	Moderate	3
13.	16	Moderate	2
14.	14	Severe	2
15.	12	Severe	3
16.	6	Severe	1
17.	8	Severe	3
18.	14½	Severe	3
19.	15	Severe	3
20.	8	Severe	1
21.	8	Moderate	2
22.	24	Severe	0
23.	6	Moderate	2
24.	21	Severe	2
25.	10	Severe	2

TRAUMATIC EVISCERATION 1944-45
312 CASES

Evisceration, for the scope of this paper, is defined as the presentation of an abdominal viscus through a missile tract to the outside of the abdominal cavity; the missile tract must interrupt the continuity of all layers of the abdominal wall.

In a series of 3154 traumatic abdominal and thoraco-abdominal cases there were 312 cases of evisceration. The 312 cases were subdivided, in reference to the presenting viscus, into the following categories:

TABLE I

Frequency of Organ Evisceration

Viscus	No. Cases	% Total	Deaths	Mortality
Small Bowel	123	39.4%	43	34.9%
Omentum alone	86	27.6%	32	37.2%
Colon	38	12.2%	21	55.2%
Small Bowel and Colon	24	7.7%	14	58.3%
Stomach	9	2.9%	3	33.3%
Liver	7	2.2%	3	42.8%
Stomach, Colon and Small Bowel	5	1.6%	2	40.0%
Spleen	3	.96%	0	0.0%
Colon and Liver	3	.96%	3	100.0%
Stomach and Colon	2	.62%	2	100.0%
Liver and Small Bowel	1	.32%	0	0.0%
Spleen and Stomach	1	.32%	0	0.0%
Spleen and Colon	1	.32%	0	0.0%
No Record	9	2.9%	3	33.3%
Total	312	100.0%	126	40.3%

The frequency of evisceration of an organ varied in regard to its mobility, volume, and in reference to the site and size of the tract. The small bowel alone, the omentum alone, the colon alone, and the small bowel and colon in combination, comprised 87% of the total of eviscerations.

MORTALITY

Case fatalities included were those cases which died within the echelon of the Field Hospital. Fatalities subsequent to evacuation were not included. A mortality rate, for this specific group, of 40.3% was appreciably higher than the rate of 24% for the total group of 3154 cases.

Traumatic Evisceration (Mortality, contd)

Omental Evisceration Only

Thirty-two deaths in 86 cases, a rate of 37.2%, occurred in the group in which the omentum alone was eviscerated. Twenty-four of these deaths occurred within the first two postoperative days, and were attributed to the shock syndrome. The term "shock syndrome" is applied to those cases which arrived in critical condition, did not appreciably improve following surgery, and died within the period limited by the second postoperative day.

Two deaths which occurred on the **ninth** postoperative day were attributed to peritonitis. Both cases had combined perforations of stomach and colon. Of the remaining six deaths, four were attributed to causes other than peritonitis. The cause of death was not recorded in two cases. The number of deaths, two, 6.2%, attributed to peritonitis, corrected for no record cases to within the range 6.2%-12.5%, did not exceed the mortality rate of peritonitis 12.04%, in the over all group.

The data indicated that the evisceration of omentum alone was significant in reference to the severity of the abdominal wound, and was not significant as an added contaminating factor. A subsequent allusion is made to the effect of evisceration upon the state of shock.

CASES EXCLUSIVE OF OMENTAL EVISCERATION

Exclusive of cases in which omentum alone presented, 226 cases remained in which an abdominal organ was extruded. Ninety-four deaths, a mortality rate of 41.5%, occurred in that group.

TABLE II

Principal Cause of Death

Principal Cause of Death	Total	%	Day of Op-1,2 PO	3rd PO	4th PO	5th PO	6th PO	7th PO	8th PO	9th PO	over	No Rec
Shock Syndrome	59	62.7	59									
Peritonitis	10	10.6		2		1	1	1	2	1	2	
Anuria	5	5.3			3	1			1			
Pulmonary Embolus	4	4.2			1	1	1		1			
Pneumonitis	3)	4.2		1		2						
Empyema	1)							1				
Thrombosis Inf. Mesenteric Vein	1	1.06	1									
Brain Injury	1	1.06	1									
Intestinal Obstruction	1	1.06					1					
Jaundice Edema	1	1.06							1			
No Record	8	8.5		2	1	2					2	1
TOTAL	94	99.74	61	5	5	7	3	2	5	1	4	1

Traumatic Evisceration (Cases Exclusive of Omental Evisceration, contd)

The number of deaths attributed to peritonitis was 10 or 10.6% of the total deaths within this group, corrected for no record cases to within the range 10.6%-19.1%, was perhaps higher than the mortality figure for peritonitis for the over all group.

The incidence of pulmonary emboli was four or 4.2% of deaths in the group, and thrombosis of the inferior mesenteric vein occurred once.

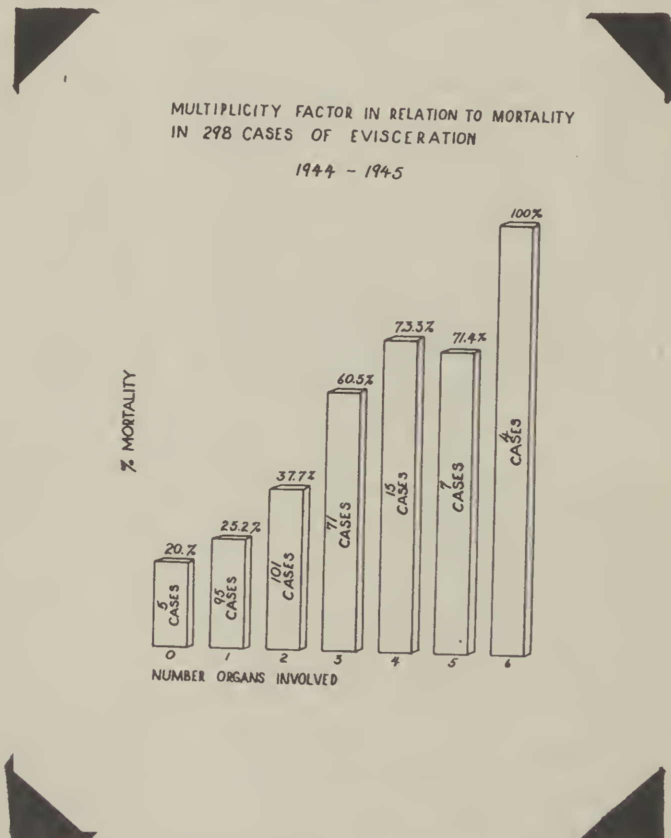

Figure 28 Multiplicity Factor in Relation to Mortality in 298 Cases of Evisceration. 1944 - 1945.

The numerical incidence of injury to abdominal organs, with reference to those wounded singly, or to those wounded in combination as two, three, four, five or six, and alluded to as the multiplicity factor is recorded in Table III.

Traumatic Evisceration (Cases Exclusive of Omental Evisceration, contd)

TABLE III

Multiplicity Factor

Number of Injured Organs	Total Cases	Lived	Died	Mortality Rate	No Record
0 Organs	7	4	1	20.0%	2
1 Organ	97	71	24	25.2%	2
2 Organs	106	63	38	37.7%	5
3 Organs	74	28	43	60.5%	3
4 Organs	16	4	11	73.3%	1
5 Organs	8	2	5	71.4%	1
6 Organs	4	0	4	100.0%	0
Totals	312	172	126		14

In this table, a progressive upward trend of the mortality rate occurred, when the rate was plotted against the number of abdominal organs which were injured. This trend supports the contention that an index of the severity of a battle casualty was proportional to the number of abdominal organs injured.

The elapsed time between wounding and surgery is referred to as "time lag". The effect of time lag upon mortality rate in this group of cases is reflected below:

TABLE IV

Time Lag

226 Cases	0-6 hrs	6-12 hrs	12-18 hrs	18-24 hrs	Over 24	No Record
Total	77	94	16	6	10	23
Living	48	52	11	4	6	NR
Dead	29	42	5	2	4	NR
Mortality	37.6%	44.6%	31.3%	33.3%	40.0%	

The variable nature of this curve (see Figure 29) suggests that a large combination of factors affected it. The most apparent of these factors are two: (1) the fact that a high percentage of the severely wounded, who were seen only in the short time lag period, had wounds the lethality of which was not altered by surgery, (2) that the more lightly wounded, relatively, died after more elapsed time, and in a lesser proportion.

Probably not all of the wounded would have died within a 10-day period if they had not been operated upon, and certainly surgery had no effect in altering the lethal nature of the wound in many of the severely wounded.

Traumatic Evisceration (Cases Exclusive of Omental Evisceration, contd)

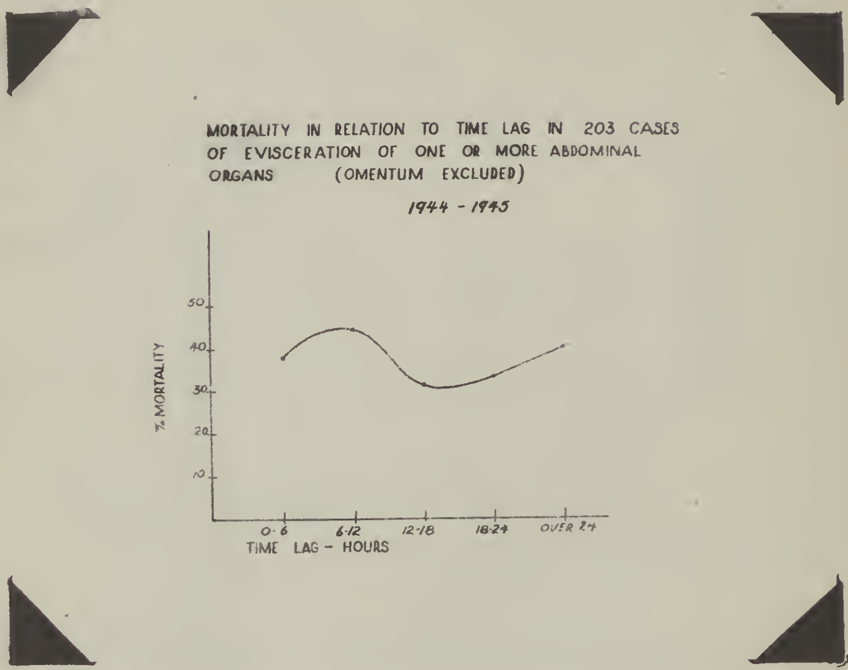

Figure 29 - Mortality in Relation to Time Lag in 203 Cases of Evisceration of one or More Abdominal Organs. (Omentum excluded) 1944 - 1945

EVISCERATION OF THE SMALL BOWEL

The cases involving the small bowel presented an opportunity to consider the effects of evisceration without the compounding effect of complex factors because in 41 instances of the total of 123, the small bowel was the sole organ eviscerated, and there were no complicating abdominal injuries. In each of the 41 cases, the small bowel itself was wounded. Thirty-three cases lived, eight died, with a mortality rate of 24.2%.

Of the eight deaths, four died within the first two postoperative days, of the shock syndrome. The role of peritoneal contamination by small bowel content may here have been manifested, as save for the evisceration itself none of the other complicating factors were present. Two cases died of peritonitis on the eighth and 22nd days, respectively; one died on the fifth postoperative day, cause not stated, and the last died on the fifth postoperative day of pneumonia.

Traumatic Evisceration (Evisceration of the Small Bowel, contd)

The mortality rate of 24.2% was higher than the rate in the same category, i.e., small bowel alone wounded, in the 3154 cases. In the latter category, there were 353 cases, with a mortality rate of 13.9%.

The average time lag in these cases was short, five and two-thirds hours, indicative of the fact that these patients did not remain long in the shock ward before operation. The effect of time lag on mortality is shown in Figure 30 . Subdivision into six-hour time intervals, after the first, yielded insignificant figures in each group, and groups were combined to obtain the equivalent number of cases.

(The case which died in the 0-6 time group, died of peritonitis on the eighth day when dissolution of the anastomotic suture line took place.)

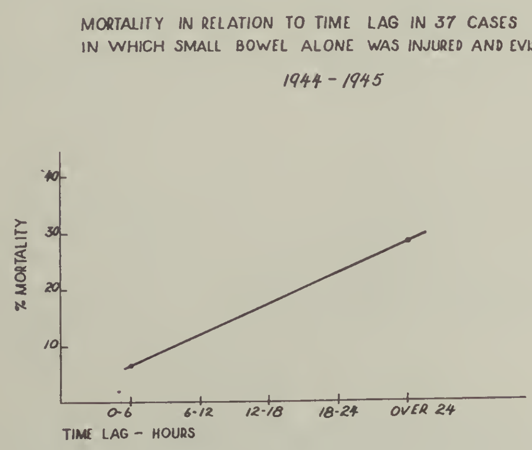

Figure 30 - Mortality in Relation to Time Lag in 37 Cases in Which Small Bowel Alone was Injured and Eviscerated. 1944-1945.

Traumatic Evisceration (contd)

EVISCERATION WITHOUT INJURY TO ANY ABDOMINAL ORGAN

The small bowel was eviscerated in four instances, the colon and small bowel in one. The average time lag per case was 20 hours. One fatality occurred, on the fourth postoperative day, of a massive pulmonary embolus.

Whether evisceration occurred at the time of, or subsequent to, wounding was not indicated. However, in no instance, whatever the actual duration of the evisceration, did such a case exhibit the signs of clinical shock, either on arrival at the Field Hospital or during the subsequent postoperative course.

THE WOUNDING AGENT AND THE SITE OF EVISCERATION

One hundred seventy-one times the wounding agent was a shell fragment, 97 times a small arms bullet, 31 times a mortar, bomb, grenade or mine fragment, and in 13 instances the agent was not recorded.

Evisceration on occasion occurred at the wound of entry if the missile was large enough. More frequently it occurred at the wound of exit. In some cases, a wide open tract existed between entry and exit wounds.

Analysis of the sites of evisceration of abdominal organs without reference to omentum, reveals the upper abdomen involved 75 times, the lower abdomen 68 times, the left flank 28 times, the right flank 13 times, the left chest 10 times, the right chest three times, abdomen site not specified 23 times, right back twice, left sacral region once, left buttock once, no record once.

SUMMARY

1. Three hundred twelve cases of evisceration were recorded; 226 of these were of an abdominal organ, 86 were of omentum alone.

2. The group mortality was 40.3%

3. Evisceration of abdominal organs occurred in five instances without other abdominal injury. No clinical shock was present in these cases.

ANESTHESIA IN 3154 ABDOMINAL AND THORACO-ABDOMINAL BATTLE CASUALTIES

INTRODUCTION

The abdominal and thoraco-abdominal battle casualties to be discussed in this survey were anesthetized and operated upon by members of the 2nd Auxiliary Surgical Group during the period 1944 and 1945. While these cases were often treated in a variety of hospital installations most of them were cared for in Field Hospital platoons and were treated by teams qualified in thoracic surgery and general surgery.

The anesthetists concerned in the care of these seriously wounded patients were, for the most part, physicians, many of whom possessed formal training, while others had moderate to no experience in anesthesia. Ideally these men should have a good general medical background and an understanding of the principles involved in caring for the disturbed physiology of these abdominal and thoraco-abdominal cases. They should be proficient in the diagnosis and treatment of shock, and the recognition and care of complications, for these casualties under consideration present incredible difficulties in the anesthetic management.

Table I indicates the hospital installations where the abdominal and thoraco-abdominal cases were cared for by the operating teams of the 2nd Auxiliary Surgical Group in 1944-45.

TABLE I

Types of Installations Treating the Priority Combat Casualties in this Survey

	1944	Percent	1945	Percent	Total	Percent
Field Hospital	2096	87.95%	755	97.92%	2851	90.39%
Evacuation Hospital	220	9.23%	12	1.55%	232	7.35%
Casualty Clearing Station, (Br.)	57	2.39%	0	.0%	57	1.80%
Clearing Station	2	0.08%	4	0.52%	6	0.18%
Medical Battalion	4	0.16%	0	.0%	4	0.12%
Not recorded	4	0.16%	0	.0%	4	0.12%
Total	2383		771		3154	

As may be seen from the above table most of the cases were treated in the Field Hospital, while the Evacuation Hospitals occupy second place.

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties.

AGE FACTOR

The age groups dealt with in this series, as would be expected in any report of military surgery, fall in the lower brackets. There were some cases above 40 and below 18 years of age. These were civilians for the most part. The following table gives a breakdown of this factor.

TABLE II

Age	No. of Cases
0 - 20	707
21 - 25	987
26 - 30	591
31 - 35	250
36 - 40	78
41+	42
No record of age	499
Total	3154

TYPE OF PATIENT

Types of cases considered are limited to, (1) Abdominal, (2) Thoraco-abdominal. These casualties were screened from the run of the mill cases at the Divisional Clearing Stations and transfered with minimum delay to the adjoining Field Hospital Platoon, where facilities and personnel for immediate definitive care were available. These cases offered a challenge to all those responsible for their care. Each one presented a problem. Time elapsed from time of injury to time of admission varied from 15-30 minutes to 30-40 hours according to distance from the front, tactical situation, terrain, condition of roads, weather, and efficiency of the Divisional medical organization. Extent of injury varied from a single penetration or perforation of a single viscus to damage to many organs. Thoraco-abdominal wounds were common. All types and conceivable combinations of associated injuries were encountered in conjunction with the two main types of casualties under consideration. All degrees of shock were seen and some degree of shock or an incipient shock state was more commonly present than absent. Some sort of resuscitation therapy was deemed necessary for the majority of patients. The following table gives blood pressures on admission to the hospital of 914 abdominal cases, representative of this series, with the percentage total of each group:

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties.

TABLE III

Representative Blood Pressure Readings

Blood Pressure (Systolic)	Percentage of Total
0 - 40	14.6
41 - 70	12.7
71 - 100	26.1
101 - 120	46.6

Further complicating factors of these cases were fatigue, exposure and improper diet over considerable periods of time. This section cannot atempt to give more than this brief picture of the type of patients handled. Detailed information may be had by consulting other sections of this report*. The following table gives incidence and percentage of the total of the two types of cases:

TABLE IV

Types of Cases

Type	No.	Percent of Total
Abdominal	2315	73.39
Thoraco-abdominal	839	26.61
Total	3154	

AGENTS AND METHODS

The choice of agents and methods used was limited by what was available. Agents and equipment were available for administration of: 1. Chloroform, ethyl chloride, and ether by open drop. 2. Nitrous oxide and oxygen by closed, circle flow, absorption method. 3. Nitrous oxide, oxygen, and ether by closed, circle flow, absorption method with Heidbrink and McKesson machines. 4. Ether and oxygen by closed, to and fro, absorption method with the Beecher model machine. 5. Pentothal by vein. 6. Procaine and pontocaine by intrathecal injection. 7. Procain for local, regional, or field block. 8. Cocain for topical application.

*See section on "Preoperative Care of the Patient", page 23 .

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties. (Agents and Methods cont'd).

Chloroform was used as an induction agent in one case. No reason for choice of this agent was given on the record of this case. The dangers of this agent have been too well known for a long time in the experience of surgeons and anesthetists to warrant consideration as an anesthetic for use in patients of the type discussed here.

Pentothal was not suited to this work. All the generally accepted contraindications to its use were present in these casualties. The surgery was formidable in nature and time consuming. Average time of operation was two and one-half to three hours. Hemorrhage before admission was the rule and further blood loss could be expected during the major surgery to come. Incidence and degree of shock has already been mentioned. Varying degrees of anoxia were common because of hemorrhage and shock, accumulated secretions in the tracheo-bronchial tree, hemothorax and pneumothorax, painful respiration, and various other derangements of cardiorespiratory physiology. Muscular relaxation was necessary, particularly during the periods of exploration and closure in abdominal cases. Pentothal could not provide this in safe dosage. Tracheal intubation was considered essential. Intubation is not as easily accomplished under pentothal as some other agents because of the poor relaxation of the muscles of the jaw and irritability of the larynx. Intubation under pentothal is followed by severe "reaction" to the tube and this recurs on movement of the catheter as when the patient is shifted on the table or when the patient's head is turned.

Pentothal was used 49 times in 2383 cases (2.05%) in 1944 as an induction agent followed by open drop ether or ether-oxygen in a closed system. In 1945 it was not used at all in 771 cases. We are aware of some few who think pentothal desirable for the severely wounded. We are not in accord with this view. We are also aware of reports which state that pentothal comprised as high as 95% of total anesthesia in forward surgery. This high figure may be due to the types of cases handled, problems of supply, or location where work was done.

Unsuitable as this agent may be for non-transportable or first priority cases its value in the lightly wounded and properly selected moderately wounded cases, which two groups add up to the bulk of casualties, make it possibly the greatest single advance in war anesthesia.

Spinal anesthesia was also unsuitable for this type of work because of length and variability of time required for completion of cases, unstable cardiovascular balance in the patients due to factors already mentioned, frequency of associated wounds in areas

not anesthetized by this method, and the undersirability of the conscious state in an apprehensive patient just removed from the battlefield. This method was used only two times in a total of 3154 cases. Both of these cases were in excellent condition pre-operatively and readily recognizable as having minimal intra-abdominal injury.

Nitrous oxide (with oxygen) was not used as the sole anesthetic agent in any of these cases. Because of the long duration of anesthetics, the necessity for relaxation, the severity of the wounds and the high incidence of shock, we thought that these patients deserved the highest concentration of oxygen we could provide to compensate as much as possible for their decreased oxygen carrying powers. Nitrous oxide was of great value as an induction agent. Concentrations of 60 - 75 percent nitrous oxide were used. No trouble was encountered in the brief length of time required for induction. Some were hesitant to use nitrous oxide for induction at first but its use gradually became general. It was used in this way in 83.27% of cases in 1945 as compared to 54.80% in 1944. Ethyl chloride was used extensively as an induction agent. It performed this function satisfactorily when cautiously administered. However, it was not used ordinarily in the cases of very poor risk.

Procaine was used for regional or field block anesthesia in only five cases. It is regreted that this procedure in combination with a light general anesthetic was not given an adequate trial in the management of these cases. In retrospect, this procedure appears to have great potentialities.

Cocaine was used in the usual manner in bronchoscopies on conscious patients. Occasionally it was used to facilitate a difficult intubation.

Open drop ether did not occupy as prominent a place as might be expected. The use of ether in this manner decreased from 12.5% of the cases in 1944 to 2.72% of cases in 1945. The figure for 1944 would have been much lower had gas machines been more plentifully supplied at that time.

The most satisfactory anesthetic for severely wounded battle casualties in our experience was an induction by means of nitrous oxide-oxygen with maintenance by ether-oxygen in a closed, carbon dioxide absorption system. We do not think this indicates that the millenium has been reached in anesthesia for these types of war injuries. Toxic effects of ether on the heart, liver, and kidneys are realized. This choice of anesthesia was prompted and became predominently in use because of availability, satisfactory tolerance by the patients, simplicity of administration, and its wide margin of safety. The last two assume great

importance in view of the fact that this work was done by approximately 45 anesthetists of variable training, experience, capabilities, and judgement.

The need for making use of the advantages of closed anesthesia was magnified in cases of precarious nature. Conservation of body heat and moisture, high oxygen content, control of carbon dioxide content, ease of attaining and maintaining desired levels of anesthesia, control of respiration where necessary, and positive pressure were more than mere desirable features.

Employment of intratracheal technic was considered essential. Assurance of a patent airway was obtained, no matter the position, giving the anesthetist sufficient freedom of action to attend to the multiple infusions of blood. Aspiration of blood and accumulated secretions from the trachea was easily accomplished via the intratracheal tube. Controlled and aided respiration by positive pressure was facilitated. Desired levels of anesthesia could easily and quickly be reached. Increased smoothness of respiration was of value to the surgeon, particularly in abdominal surgery.

A striking increase in the use of intratracheal anesthesia was noted. In 1944 intubation was employed in 88.45% of cases whereas, in 1945 it was employed in 100% of recorded cases of abdominal and thoraco-abdominal procedures.

Certain trends may be noted by comparing figures for 1944 and 1945 in the following tables.

TABLE V

AGENTS USED

	1944	%	1945	%	Total	%
G.O.E.	1306	54.80	642	83.27	1948	61.76
Ether	752	31.55	48	6.22	800	25.36
C_2H_5Cl-Ether	224	9.40	57	7.40	281	8.90
Pentothal-Ether	49	2.05	1	0.12	50	1.58
Ether-Procaine	3	0.12	0	.0	3	0.10
$CHCl_3$-Ether	1	0.04	0	.0	1	0.03
G.O.E.-Pentothal	1	0.04	0	.0	1	0.03
G.O. +	1	0.04	0	.0	1	0.03
Oxygen ++	1	0.04	0	.0	1	0.03
Procaine (Local)	5	0.20	1	0.12	6	0.19
Spinal	2	0.08	0	.0	2	0.06
Spinal-Pentothal	1	0.04	0	.0	1	0.03
Pentothal +++	1	0.04	0	.0	1	0.03
Not Recorded	36	1.51	22	2.85	58	1.83
Total	2383		771		3154	

+ Vomited during induction, aspirated gastric contents, and died.

++ Patient moribund and unconscious.

+++ Simple debridemant of wound of entrance in a right-sided thoraco-abdominal case.

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties.
(Agents and Methods cont'd.)

TABLE VI

METHOD

Method	No. cases in Year 1944	Percentage of use	No. cases in year 1945	Percentage of use	Total No. cases per Method	Total Percentage of use
Closed	2028	85.10	727	94.29	2755	87.34
Open	298	12.50	21	2.72	319	10.11
Semi-open	7	0.28	0	.0	7	0.22
Others	14	0.56	1	0.12	15	0.47
Not Recorded	36	1.51	22	2.85	58	1.84
Total	2383		771		3154	

TABLE VII

INTUBATION

	1944	Percent	1945	Percent	Total	Percent
Endotracheal	2108	88.46	749	97.14	2957	90.57
Non-endotracheal	239	10.83	0	.0	239	7.59
Not recorded	26	1.51	22	2.85	58	1.84
Total	2383		771		3154	

PREOPERATIVE MANAGEMENT

In the well organized and fully staffed Field Hospital Platoon, the abdominal and thoraco-abdominal casualties were placed in the capable hands of a shock team immediately after arriving from the clearing station. The details of preoperative management are fully discussed in another portion of this study entitled "The Problem of Shock Therapy in Abdominal Wounds", pages 169 to 186. The anesthetist did not have the opportunity to study his patient during a "push" until the restorative therapy had readied him for surgery. At this time, the need for preanesthetic medication was determined and the necessary drugs were administered (intravenously, in the majority of cases). This consisted of atropine gr. 1/100 in most instances together with morphine when, and in dosage as was deemed necessary. This is more fully discussed in the remarks on premedication (page 61 "General Considerations of Anesthesia in War Casualties").

These circumstances were not always encountered, In the absence of a shock team or when the flow of casualties was extremely heavy, the surgeons and the anesthetists performed the resuscitation. Because of the possibility that the responsibility of preoperative management may be his, and because of his interest in administering anesthesia to a patient in the best possible condition, the anesthetist should be familiar with shock therapy.

Some of the thoraco-abdominal patients were unable to clean their respiratory passages of blood and mucus and required tracheo-bronchial suction in order to improve the respiratory exchange. This was done by blindly passing a long no. 16 catheter (with a hole in its side near the proximal end and several holes in the distal end) nasally and sucking out the foreign material. One application of the suction tube was sometimes sufficient, but this procedure was repeated when there was a reaccumulation of fluid. Respiratory physiology was further enhanced by preoperative thoracentesis when it was disturbed by pneumothorax or hemopneumothorax.

Coughing was facilitated and pain controlled in selected cases by intercostal nerve blocks. Unilateral blocks were used for chest pain and bilateral blocks for abdominal pain. Some anesthetists requested the patients to cough and clear the tracheo-bronchial tree and pharynx voluntarily before beginning the anesthesia. This was an important step because they might have been lying quietly in a depressed state for many hours.

OPERATIVE MANAGEMENT

The management of these battle casualties during anesthesia and surgery consisted of, in the main, a continuation of the resuscitation. Pain was abolished by the anesthesia, repair of the damaged organs was accomplished by the surgery, restoration of the blood circulation volume was continued by means of the infusions and the re-establishment of a more normal metabolism was aided by the administration of a high concentration of oxygen.

The anesthetist did not transfer the patient to the operating tent until his equipment and the surgical instruments were ready for use. Thus, there was no interruption of therapy. For example, oxygen administration was discontinued only while the patient was transported by the litter bearers.

As a rule the inductions were not difficult. Many of the wounded had gone for long periods without sleep and were exhausted. Patients

in shock or who recently have been in shock are generally easy to anesthetize. An attempt was made by a number of the anesthetists always to use 30% or more oxygen and the others did not use less than 20% oxygen for the nitrous oxide-oxygen inductions.

The severe excitement stage was a most unusual occurrence in contrast to its relative frequency in this group in civilian practice. We expected more violent excitement stages because of the noise in a busy surgical tent and the disturbance created by our own and enemy artillery. As a precaution, someone supported the extremity receiving infusions to make certain that the needle was not dislodged by sudden involuntary movements.

Anesthesia was maintained in the lightest planes compatible with the surgery being done. These patients could not tolerate deep planes of anesthesia for more than brief periods of time. To facilitate intra-peritoneal interference in light periods of anesthesia, curare extract was used in 26 patients for abdominal relaxation with excellent results. One anesthetist of this Group was authorized to use this drug for clinical trial*.

A clear airway was always assured. The majority of the abdominal and all the thoraco-abdominal cases were done with the endotracheal technic. It was noted that when all the anesthetists had gained proficiency in the last stages of the European War, all the abdominal cases were also anesthetized with the endotracheal technic. The tracheo-bronchial toilet was an important part of the anesthesia because many of the winter campaign casualties had bronchitis and thick mucoid material was frequently found. Most of the endoscopies were done on the thoraco-abdominal cases.

Citrated blood in amounts necessary to maintain an adequate circulating blood volume was administered throughout each operation. The largest amounts used (6,500 c.c.) were in patients with injuries to large vessels. The average quantities of blood and plasma administered to each type of case are recorded in Table I in the section on shock (page 122 to 131). Dextrose and saline solutions were used less frequently and only for combatting dehydration. Stimulating drugs were not used as a general rule in the average case. Specific therapy with penicillin or the sulfonamides was instituted during the operation by the anesthetist at the surgeon's request.

*The Use of Curare for Abdominal Surgery in Severely Wounded Battle Casualties. Doud, E. A. and Shortz, G. K.: In press.

The fall in blood pressure occasioned by changing the position of these patients was noted by all the anesthetists. The greatest declines occurred after turning them from the supine to the prone positions or vice versa. Changes also occurred when they were turned onto the side. This phenomenon is direct evidence of the instability of the vasomotor systems of the severely wounded, anesthetized patients. Great care must be used to turn them slowly and gently to minimize this decrease in tension. Unnecessary turning of the patient should be avoided.

The foot end of the litter was often raised before the induction of anesthesis to avoid interrupting the surgery by waiting until impending shock necessitated the change in position. There is no question that this position was helpful in combating shock.

POSTOPERATIVE CARE

The postoperative care of the patient is the joint responsibility of the anesthetist and the surgeon. Usually the anesthetist is concerned only with the prevention of shock and pulmonary complications. However, in times of stress the anesthetist may be forced to take over full postoperative care of some patients.

Shock is one of the most difficult conditions that the anesthetist has to prevent and treat. It usually occurs in those patients with very severe wounds or in those who have been in prolonged shock and have only partially recovered, or in those cases that go into shock during surgery.

Oxygen should be used postoperatively in all the cases just mentioned. Every effort must be made to prevent anoxia. The anoxia can be very insidious and progress to a fatal end if unchecked. Anoxia, when it once begins, develops a vicious cycle that becomes progressively worse. It behooves the anesthetist to see to it that everything is done to insure sufficient respiratory exchange and adequate oxygenation.

The proper position in which to place these patients often presents serious difficulty. In cases with thoraco-abdominal injuries, it is not always practical to use Trendelenberg position because this increases respiratory difficulty. Therefore, these patients should be kept as near horizontal as they will comfortably tolerate. These who do not present a shock picture may well be placed in Fowler's position, in which their respiratory exchange is more efficient.

Nerve block for relief of pain is often indicated. In thoracic cases some teams anesthetized the intercostal nerves while they were

exposed during the operation, or did a block before the patient was removed from surgery. When the patient begins to experience pain again, a block should be done and repeated when necessary. If the patient was allowed fluids by mouth, nembutal in 1½ gr. doses was given when multiple blocks were indicated. If nembutal could not be administered, pentothol was available in the event that the patient developed a procaine reaction. This should be kept in mind especially if more than one ounce of 1% procaine is to be used. The intercostal or paravertebral technic was used in most phases, but in the latter part of the war epidural blocks were used in some cases. These were instances where bilateral blocks would ordinarily be indicated for the upper abdomen. The fact that only one puncture is necessary is strongly in its favor over multiple punctures for there is always a chance of missing one nerve and losing much of the effect from the block. Once the technic is mastered, it is well worth while in selected cases.

The careful use of morphine for the relief of pain without depressing respiration is very essential. Less narcotic is required if blocks are used and repeated as indicated. The use of small doses of morphine sulfate intravenously during the early postoperative period is probably the safest and best method to get accurate evaluation of its effectiveness. Atropine has little use unless the patient has a tendency to produce large amounts of mucoid secretions. The use of ephedrin sulfate, or other pressor drugs, intravenously and subcutaneously in repeated doses was not effective in maintaining the blood pressure of these shocked patients.

The use of fluids, chiefly blood and plasma, was very important. The patients who were in shock usually had received large amounts of fluid preoperatively and during the operation, so that it was difficult to decide how much to give and which colloid solution was indicated. Frequent hematocrit estimations were used to determine the relative proportions of plasma to whole blood to be given. The fluid intake and output was another check which, after the first 24 hours, was used as a guide in treatment.

In both thoracic and abdominal cases there are factors present which predispose the patient to both atelectasis and pneumonia. The chief interest of the anesthetist is to prevent these complications, and if they do occur, to institute early treatment.

The normal depth of respiration and an effective cough must be maintained to insure a clear tracheobronchial tree. Relief of pain with adequate support to the injured site and operative incision are necessary. Pain relief has been discussed. Support may be accomplished

by dressings, but if they restrict respiratory excursion, they should be avoided. Firm manual pressure to the site is the best aid in assisting the patients in their efforts to cough. Soon they learn to support themselves, especially if they have abdominal wounds. Frequent coughing and changing of position are important. In a few patients with multiple wounds it is difficult to change their positions; particularly if they are in large bulky casts.

A few patients refuse to cough or cannot cough adequately. In this group of cases, tracheal aspiration is necessary. Aspiration using a soft rubber catheter passed through the nose into the trachea is a relatively simple procedure. Usually no anesthetic is necessary. Introduction of the catheter into the trachea often causes severe paroxysms of coughing. Many times this alone is sufficient to clear any obstructions present. Suction through the catheter removes the obstructing material that has been loosened by the coughing.

Those patients who are "wet", and are unable to clear effectively the tracheabronchial tree may necessitate repeated tracheal aspirations. If this is necessary, the catheter may be left in the trachea and oxygen administered intratracheally between aspirations. On a few occasions those patients who are persistently "wet" have been benefitted by oxygen under slight pressure (3 - 6 cm. water) over a period of time. A closed system of oxygen is used with a CO_2 absorber. At first the patient resists but soon he finds it much easier to breath and tolerates the system quite well. Some degree of relief has been noted in almost all cases. It may be necessary to continue this treatment 24 hours or longer depending on the case. Most patients who are benefitted by this treatment soon appreciate its value and request it when the mask is removed during the "rest" periods.

Most patients need only one tracheal aspiration to convince them of the importance of coughing. A few are not benefitted by it and the obstruction may persist. These cases require bronchoscopy. Usually the surgeon performs the bronchoscopy under topical anesthesia, although in many cases this has been done by the anesthetist.

The procedures discussed thus far have been chiefly carried out by the anesthetist after discussion with the surgeon. Occasions have arisen when for one reason or another, the anesthetist was called upon to do more of the postoperative procedure. Only those concerned with cardiorespiratory physiology will be mentioned. Thoracentesis is necessary for the removal of fluid and/or air to allow for greater pulmonary exchange. Nasogastric suction is important for the relief and prevention of abdominal distention. The maintenance of an adequate fluid balance, and medication when it is indicated to treat complication, are both adjuncts in the treatment of these casualties.

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties (cont.)

COMPLICATIONS

An attempt has been made to determine the complications resulting from or associated with the anesthesia in this group of abdominal and thoraco-abdominal cases. This has not been too successful for the following reasons: In the first place the records failed to state the complications in all cases. Secondly, many records listed the complications incompletely. Thirdly, progress notes were missing in many instances. Again, some of the cases developed postoperative pulmonary condition which in our opinion, after studying the records, were not related to anesthesia. For that reason, an arbitrary time period of 48 hours was taken, after which pulmonary conditions were not regarded as pertinent to anesthesia.

Many of the cases resulting in death to the patient were found at autopsy to have a terminal "bronchopneumonia". Unless death resulted within 48 hours postoperatively, this condition was not recorded in our table.

In many reports there was a striking variation in the surgeon's diagnosis of the condition. As far as possible these were examined and allotted to what we believed to be the proper heading.

TABLE VIII

Postoperative Complications Related to Anesthesia

Atelectasis (recovery)	57
Atelectasis (with other fatal complications)	12
Lobar pneumonia (recovery)	12
Lobar pneumonia (cause of death)	8
Lobar pneumonia (with other fatal complications)	3
Broncho pneumonia (recovery)	21
Broncho pneumonia (cause of death)	2
Broncho pneumonia (with other fatal complications)	19
Blast injury to lungs (recovery)	1
Blast injury to lungs (cause of death)	5
Blast injury to lungs (with other fatal complications)	5
Aspiration gastric contents (death on table)	4
Aspiration gastric contents (death on ward)	2
Aspiration gastric contents (uneventful)	4
Pulmonary edema (recovery)	3
Pulmonary edema (fatal) *	1
Death on table during bronchoscopy	2

* Died four hours postoperatively after a secondary operation under pentothal during which he vomited and aspirated gastric contents.

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties (Complications, contd)

As can be seen, the largest group of recorded complications comprises the condition of atelectasis. Most of these were temporary and cleared uneventfully. There were no deaths from this state, per se, within the stated time limit, although there were 12 showing this condition at autopsy. In view of the severe wounds and other serious postoperative conditions in these cases, atelectasis was thought to be merely an accompanying, and not causative, factor in their deaths.

We believe that prophylaxis against atelectasis is important. This can be carried out in the operative as well as postoperative period by means of artificial respiration, administration of morphine for the relief of pain, and bronchoscopy. Atropine administered preoperatively, is effective in checking the cause of atelectasis. However, if the patient already presents signs of increased pulmonary transudation, atropine is probably best avoided. Having the patient voluntarily cough on the ward, administration of oxygen and turning him frequently, will also militate against this condition.

The infectious states of lobar and broncho pneumonia fortunately have not been as common as might be expected with soldiers fighting in intolerable weather, and suffering long periods of exposure both before and after wounding. Many patients arrive at the hospital with an already existent upper respiratory infection or tracheobronchitis. Following a prolonged anesthesia and operation, pneumonia would not have been a surprising event prior to the routine administration of penicillin and sulfa drugs, and the close observance of prophylactic postoperative measures.

Blast injuries to the lungs are discussed under "General Considerations of Anesthesia in War Casualties" (page 63). One thing is certain from the few cases recorded as such, and that is that many were unrecognized or at least no notation made of them. Perhaps this was due to the fact that the degree of blast varied and that the minor cases gave minimal trouble. Severe bilateral pulmonary blast should offer no problem in diagnosis, but the problem is anesthetizing such a case without losing the patient on the table from pulmonary edema. These patients do not tolerate anesthesia well, particularly ether, and every effort must be made to maintain adequate respiratory exchange, not only during the operation but postoperatively.

One of the most important preoperative therapeutic measures is that of emptying the patient's stomach. This has a dual purpose: 1) preventing gastric dilatation, 2) removing the possibility of vomiting under anesthesia. In spite of this widely held view there were 10 recorded

cases which vomited under anesthesia and aspirated gastric contents, with six of these being fatal accidents. Two of these occurred postoperatively on the ward before the patients had completely reacted, and must be ascribed to inadequate supervision.

Of the four cases noted of pulmonary edema, one was fatal, and resulted from vomiting and aspiration following pentothal sodium for a secondary operation.

Finally, there were two cases of death during bronchoscopy at the conclusion of the operation. This is 0.4% of the 436 recorded bronchoscopies (known to be very incomplete) as determined in the survey by the thoracic surgeons. Both cases were attributed to the vago-vagal reflex syndrome, which must be guarded against as a forseeable catastrophe. This is best accomplished by intravenous atropinization of the patient just prior to the procedure, and by rapid careful bronchoscopy. Light anesthesia at this stage is preferable since the nechanical stimulation of the cough reflex assists in clearing the air passages.

DEATHS ON THE OPERATING TABLE

In any large group of seriously wounded battle casualties, there are some who are so badly off that they die shortly after admission to the Field Hospital. These we have come to designate as "fatally wounded". It is small wonder, therefore, that many die on the operating table during their surgery in spite of the most heroic measures to preserve their lives. In the series of cases under consideration, 68 such deaths occurred. This is 2.15% of the total series. Of these, four resulted from vomiting and aspirating gastric contents, while two expired during bronchoscopy.

The chief cause of death in these cases is shock, while infection and acute hemorrhage are important factors. Sudden change of position, during the course of a long operative procedure on a patient in poor condition, has resulted in death on the operating table. In theory this is said to be due to sudden diminution of circulatory volume by "internal bleeding" into muscles and widely dilated capillary beds. It has been suggested that in addition to extreme care in turning these patients ephedrine gr. 3/4 be given a few minutes previously in an attempt to produce a general vasoconstriction and increased cardiac output, thus sustaining the blood pressure.

Every means of resuscitation known to the anesthetist must be employed in the effort to keep these patients alive. Oxygen, artificial

respiration, coramine, ephedrine, adrenalin, infusion of blood in every extremity and sternal infusion if possible, should be attempted. All too often, unfortunately, nothing seems to help very much, and in spite of every effort the patient succumbs to the gravity of his wounds.

DURATION OF ANESTHESIA

It is well recognized that the longer the operating time, and consequently anesthesia time, the more apt the patient is to leave the table in poor condition, and also, the more he is subject to postoperative complications. However, in dealing with these badly wounded men, especially those with multiple wounds, there are very few "short cuts" in the surgery which can lessen the operating time. The best that can be done under these circumstances is for the surgeon to work quickly yet carefully, while the anesthetist does everything to maintain a viable patient. Because of the personal equation involved, no two surgeons work alike or at the same speed, nor are the wounds of any two patients exactly similar in extent or number. For that reason the length of operating time on these abdominal and thoraco-abdominal cases is bound to vary between wide extremes. Indeed the extremes have been found to extend from 45 minutes to six hours, depending upon the severity of the wounds and their multiplicity. The average operating time for these patients was determined to be between 2 1/2 to three hours, while the length of anesthesia time was approximately 10 to 15 minutes longer.

SUMMARY AND CONCLUSIONS

1. The anesthesia employed in 3154 cases of abdominal and thoraco-abdominal combat casualties is reviewed. Most of these were done in Field Hospitals during the years 1944-45. See Table I.

2. Trained anesthetists should be used in these forward installations.

3. The age groups of these patients are noted in Table II.

4. The agents and methods available throughout the period are discussed. N_2O-O_2-ether endotracheally by the closed CO_2 absorbtion technique is judged to be the method most frequently used, and least injurious to the patient. Tables supporting these views are included.

5. Preoperative management is considered with reference to medication, antishock therapy, emptying the stomach, local blocks, and clearing the respiratory passages.

Anesthesia in 3154 Abdominal and Thoraco-Abdominal Battle Casualties (Summary and Conclusions, contd)

6. During the operative phase, the lightest plane of anesthesia compatible with the contemplated surgery was employed. Curare was used in 26 patients for additional relaxation with good results. Shock treatment was continued throughout the operation as needed.

7. Postoperative bronchoscopy was valuable in many cases.

8. In the postoperative period the anesthetist is concerned with pervention and treatment of complications, and continuation of shock therapy.

9. Complications as recorded in this series are noted in Table VII.

10. Deaths on operating table from shock, vomiting, and bronchoscopy are noted.

11. The average duration of anesthesia was between 2 3/4 and 3 1/4 hours.

LAPAROTOMY

INCISIONS, CLOSURES, DEHISCENCES

In the 3154 abdominal and thoraco-abdominal cases operated upon in 1944 and 1945, 2258 cases with laparotomy wounds had records sufficiently complete to allow an analysis of the type of incision and the type of closure in each instance. Inasmuch as the majority of these cases were held in the Field Hospital only for a period of seven to 14 days, it is obvious that this study would take on greater significance if a detailed follow-up could be undertaken after the cases had been evacuated, and especially, after they had reached the General Hospitals in this Theater. Probably more wound dehiscences occur after ten days than before. Any such follow-up would not relate to the incidence of incisional hernia, which, to be accurate, would require a follow-up over a period of months and years.

INCISIONS

A tabulation of the types of laparotomy incisions in this series of 2258 cases has been made. They were broadly grouped into two main classification, vertical and transverse incisions. It was found that 92% of all incisions were vertical and that only 8% were transverse in type. The former group was subdivided into midline, rectus splitting and paramedian muscle-retracting incisions. The group of transverse incisions was subdivided into subcostal, gridiron, loin and transverse anterior incisions. Midrectus, mid-midline and midparamedian incisions were arbitrarily grouped with the high rectus, high midline and high paramedian incisions as the case might be.

TABLE I

Incidence of Vertical Incisions
(2072 Cases - 92% of Total)

	No. Cases	Total Vertical Incisions
High midline incisions	150	7%
Low midline incisions	268	13%
High rectus incisions	1176	56%
Low rectus incisions	140	7%
High paramedian incisions	303	15%
Low paramedian incisions	35	2%

It is not the purpose of this paper to debate the relative merits of each of these incisions. Each has its proper place in civilian abdominal surgery. However, we feel that the most suitable laparotomy

Laparotomy (Incisions, contd)

TABLE II

Incidence of Transverse Incisions
(186 Cases or 8% of Total)

	No. Cases	Total Transverse Incisions
Subcostal	54	29%
Gridiron	46	25%
Loin	26	14%
Transverse anterior	60	32%

incision for handling war injuries of the abdomen is the vertical incision. This is true for two reasons: First, it permits upward or downward extension of the wound to allow a satisfactory approach to injuries which had not been anticipated pre-operatively. Secondly, it is undesirable to exteriorize an injured segment of colon in the exploratory wound, and by the use of a vertical incision, the lateral and medial portions of the abdominal wall are left free for the exteriorization of the colon in separate stab wounds.

As to the type of vertical incision to be used, it makes little difference whether a midline, a rectus splitting or a rectus retracting is employed so long as it is of sufficient length to permit good exposure. We will show subsequently, however, that the dehiscence rate per 100 cases is lower for high paramedian incisions than for high rectus or high midline incisions.

CLOSURES

In the surgical closure of 2258 laparotomy wounds by 34 surgical teams, a total of 40 different methods were utilized. These represented the preference of the surgeon in each instance. In general, these variations as to type of closure have fallen in to four large groups with many deviations in each group. These groups are: 1. Layer closure of the wound using catgut throughout, plus retention sutures (68%). 2. Layer closure using interrupted sutures of cotton or silk in the anterior fascia, plus retention sutures (15%). 3. Layer closure but no retention sutures (6%). 4. Mass closures with through and through sutures of heavy braided silk, steel wire or doubled silkworm gut (11%). All layer closures (2006) had retention sutures of some type except for 137 cases, or 6.8% (of the total number of layer closures). In some instances, the only part of a layer closure consisted in a running catgut suture in the peritoneum, reliance for the approximation of other layers being placed upon retention sutures incorporating skin, fascia and muscle, or just skin and fascia only. In other instances, through

Laparotomy (Closures, contd)

and through sutures incorporating all layers of the abdominal wall were used in conjunction with interrputed sutures of silk or chromic catgut in the anterior fascia only. In a few cases, interrupted cotton or silk was used in all layers including the peritoneum, without any retention sutures whatever. Also, nonabsorbable suture was used in the anterior fascia in combination with the usual running catgut suture in the peritoneum together with any one of the three methods of placing retention sutures. Mass closures alone were used employing only retention sutures of heavy braided silk, doubled silkworm gut, or steel wire.

Other variations in the layer closures consisted in placing a small penrose drain, superficial to the peritoneum and deep to the anterior fascia. In most instances the skin was left open; in others it was partially closed; and in very selected cases, without hollow viscus perforation, it was closed tightly without either a subcutaneous or a subfascial drain. The many possible combinations of these variations resulted in the 40 different methods of laparotomy wound closure.

TABLE III

Incidence of the Four Principal Methods Of Laparotomy Wound Closure

Method	No. Cases	Percent of Total Cases
Layer closure throughout, using catgut plus retention sutures	1536	68%
Layer closure using interrupted silk or cotton in anterior fascia	333	15%
Layer closure but no retention sutures	137	6%
Mass closure, through and through sutures only	252	11%

TABLE IV

Incidence of Laparotomy Wound Closures on the Basis Of the Method of Retention Suturing Used

Method	No. Cases	Percent of Total Cases
Retention sutures through skin and fascia	813	38%
Retention sutures through skin, fascia and muscle	576	27%
Retention sutures through all layers of abdominal wall with layer closure	480	23%
Retention sutures through all layers of abdominal wall, no layer closure	252	12%

Laparotomy (Closures, contd)

The surgeons of this Group feel that there is probably no satisfactory substitute for the accurate suturing of laparotomy wounds in layers, together with the employment of some method of retention suturing that will actually retain the wound. Mass closure, though rapid and having a definite place in the surgical management of the more severely wounded, is a definite sacrifice of accurate wound closure for the sake of speed. We believe that the latter should be resorted to only when the condition of the patient on the operating table is such that prolongation of the operation is likely to deny the patient his best chance for recovery. Under such circumstances, this method is not only justified but indicated.

DEHISCENCES

Thirty-six abdominal wound dehiscences, out of this group of 2258 cases, occurred in first priority hospitals, an incidence of 1.6%. This figure is accurate for first priority hospitals only. We have studied these 36 dehiscences from the standpoint of types of incisions and closures used; the frequency of involvement of intra-abdominal viscera at the time of original surgery; the recorded factors felt to contribute to or provoke the dehiscence; and the type of treatment instituted once the dehiscence was recognized clinically.

TABLE V

Incisions Used in 36 Wounds which Dehisced

	Cases with Dehiscence	Total No. of Cases	Percent
High rectus incisions	25	1176	2.12%
Low rectus incisions	3	140	2.14%
High midline incisions	3	150	2.00%
High paramedial incisions	3	303	0.99%
Left upper transverse	1	60	1.66%
Transverse upper abdominal connecting wounds of entry and exit	1	-	

Thirty of the 36 wound dehiscences were closed in layers and some method of retention suturing was used in all the layer closures except one. This particular case had a running suture of plain catgut in the peritoneal layer, interrupted chromic catgut in the anterior fascia, a subfascial penrose drain, but no retention sutures.

Laparotomy (Closures, contd)

TABLE VI

Primary Closures Used in 36 Cases With Subsequent Dehiscence

	Cases With Dehiscence	Total No. of Cases	Percent
Layer closure throughout with catgut plus retention sutures	22	1536	1.43%
Layer closure with interrupted cotton or silk in anterior fascia, plus retention sutures	7	333	2.1%
Layer closure (catgut), no retention sutures *	1	137	.73%
Mass closure with through and through retention sutures only	6	252	2.4%

* 47 of these cases were McBurney incisions for appendectomy and the remainder were negative explorations or had minimal pathology to warrant a closure of this type. For purposes of comparison, this group should be excluded.

TABLE VII

Tabulation of 36 Dehiscences in Relation to Method of Retention Suturing Used
(In one case with dehiscence, no retention sutures were used)

	Cases with Dehiscence	Total No. of Cases	Percent
Retention sutures through skin and fascia	16	813	1.96%
Retention sutures through skin and fascia and muscle	12	576	2.1%
Retention sutures through all layers associated with a layer closure	1	480	0.2%
Retention sutures through all layers - Mass closure - no layers	6	252	2.4%

Laparotomy (Closures, contd)

Incidence of Injury to Abdominal Viscera at Original Surgery in 36 Cases of Subsequent Laparotomy Wound Dehiscence

	No. Cases
Small bowel	21
Colon	17
Liver	9
Stomach	7
Kidney	4
Diaphragm	7
Spleen	2
Urinary bladder	2
Retroperitoneal hematoma	4

Causitive and Provocative Factors in 36 Instances of Laparotomy Wound Dehiscence

	No. Cases
Distention	10
Wound sepsis	7
Cough (excessive)	4
Vomiting	3
Small bowel fistula, spontaneous	3
Gastric fistula, spontaneous	1
Colostomy in laparotomy wound	1
Irrationality	3
Nutritional deficiency, severe	2
Removal entire rectus nuscle (clostridial myositis)	3

Method of Treatment in 36 Dehiscences

		No. Cases
Resuture of wound		28
Closed with T & T silk	16	
Closed with T & T wire	11	
Closed with figure of 8 silk	1	
Taping of wound		7
No treatment (patient died)		1

These 36 dehiscences occurred from one to 19 days postoperatively. The average time postoperatively was approximately eight days. All cases had abdominal pathology at the time of surgery except for one negative exploration.

Laparotomy (Closures, contd)

Death occurred in seven out of these 36 cases. In five instances the cause of death seemed to be the result of the dehiscence.

1. Death from retraction of colostomy into peritoneal cavity with fatal peritonitis (colostomy exteriorized in laparotomy wound) 1

2. Death attributable to peritonitis resulting from two leaking areas in small bowel produced by trauma against through and through wire sutures at the time of dehiscence 1

3. Death from "shock and anesthesia" on operating table at time of resuture for a complete wound dehiscence ... 1

4. Death due to aspiration of vomitus with subsequent (four hours) development of excessive pulmonary and bronchial fluid -- accident occurred at time of resuture 1

5. Death from acute mechanical intestinal obstruction secondary to partial wound dehiscence treated by taping only 1

Two additional cases developed small bowel fistulae following dehiscence. One dehiscence had been treated by resuture while the other was handled by taping only.

COMMENT

The surgeons of this Group have always been interested in the subject of laparotomy wound dehiscence for several reasons: First, because the surgical management of abdominal and thoraco-abdominal cases in forward hospitals has been our especial concern. Secondly, because of the high incidence of laparotomy wound dehiscence among the early cases, those operated upon in 1942 and 1943. Thirdly, because it was logical to expect that dehiscence would occur with considerably greater frequency in war injuries of the abdomen than in an equal number of nontraumatic abdominal cases. And fourthly, because of our desire to employ active measures to lessen the frequency of this complication.

In a series of 346 abdominal and thoraco-abdominal cases operated upon by this Group in 1943, Jarvis reported 30 laparotomy wound dehiscences in the 250 cases that lived over one week, an incidence of 12%. These cases were traced through the General Hospitals in this Theater. His report alone provoked serious thought on the subject of dehiscence and toward measures which could be utilized to prevent it.

Laparotomy (Comment, contd)

The high rate of occurence among the early cases was attributable to several factors. It was not uncommon in the early overseas experience to find laparotomy wounds closed in layers but without retention sutures. The use of retention sutures soon became a requirement prescribed in directives from the Theater Surgeon. It was not uncommon to find a damaged segment of intestine exteriorized in the laparotomy wound rather than in a separate small incision. Likewise, this practice was soon stopped. Premature evacuation of patients before the optimal time (which is usually 10 to 14 days), necessitating long ambulance rides and often over rough terrain, eventuated in directives against this. These corrective measures have helped greatly with lessening the incidence of dehiscence among war-incurred abdominal injuries.

When the above measures have been taken into consideration, there still exists a great tendency for wound dehiscence to occur in penetrating and perforating wounds of the abdomen. The massive soiling of the peritoneal cavity from hollow viscus perforation produces peritonitis, either chemical or bacterial, in a high percentage of instances. This usually results also in heavy contamination of the laparotomy wound. Clinical sepsis, with its deleterious effect on sound wound healing, is not infrequently the result. The adynamic ileus which is occasioned by peritonitis of the degree present in most of these cases necessitates prolonged nasogastric suction at a time when reserves may be critical. This may result in hypoprotcinemia, or in other nutritional deficiency states, especially Vitamin C deficiency. The incidence of postoperative pulmonary complications is not low, especially during the winter months, and a severe and protracted cough adds considerable strain to the wound. When we add to these factors the occasional necessity for premature evacuation of patients because of tactical reasons, we can readily understand why more laparotomy wound dehiscences occur in these cases than in a series of comparable size of nontraumatic conditions of the abdomen.

That we have not altogether succeeded in preventing dehiscence of laparotomy wounds is attested by the fact that 36 instances occurred in 1944 and 1945, out of a series of 2258 cases in forward hospitals alone, an incidence of 1.6%. This, of course, represents only a fraction of the total, because undoubtedly other dehiscences occurred among these patients after we had evacuated them. It is unfortunate that we do not have the complete story in regard to this group of cases because from it we would be in position to accurately estimate the true incidence of occurrence as well as the relative value of the different methods of closure.

On the basis of the 36 dehiscences which occurred while the cases were still under our observation, we can say that all of the

Laparotomy (Comment, contd)

principal methods of closure have failed once, and usually several times. Layer closures with nonabsorbable sutures of silk or cotton in the anterior fascia have shown no superiority over catgut closures. In fact, on the basis of the figures which we have, the dehiscence rate is 1.43 per 100 cases with layer closures using catgut throughout, whereas the rate is 2.1 per 100 cases where cotton or silk is used in the anterior fascia. Mass closures carried a rate of 2.4 per 100 cases, higher than either of the two principal methods of layer closure.

The dehiscence rate in relation to the method of retention suturing resulted in some interesting figures. When the retention sutures were placed through skin and fascia (either as a loop or figure of eight) the dehiscence rate was 1.96 per 100 cases; when they incorporated skin, fascia and muscle, the rate was 2.1 per 100 cases; when mass closure with through and through retention sutures was done, incorporating all layers of the abdominal wall, and without any part of a layer closure, the rate was 2.4 per 100 cases; when a layer closure (closure of one or more layers, skin usually being left entirely open) is combined with through and through retention sutures incorporating all layers of the abdominal wall, including peritoneum, the rate was only 0.2 percent. Actually, 480 cases were closed in this manner and in only one laparotomy wound did dehiscence occur. Catgut was used for the layer closure in the majority of these cases. The through and through retention sutures were handled in one of two ways. They were pulled up and tied fairly snugly in the midline, or else tied laterally over rubber tubes, one tube being placed on either side of the incision. In either method, they were pulled up and tied after the layer closure was completed. We have recorded only one case in which a mechanical intestinal obstruction was thought to have been due to retention sutures of this type. The etiology of obstruction in this case was not proved. The obstructive signs disappeared with the release of the through and through sutures on the fifth postoperative day and no obstruction or small bowel fistulation occurred subsequently. One hundred cases closed in this manner by three surgeons of the Group (and included within the total of 480 cases) had a follow-up study through the General Hospitals in this Theater. No instance of complete wound dehiscence occurred in this group of 100 cases. One case had a partial separation of the superficial layers of the wound (though the peritoneal layer remained intact) and required resuturing. A second case was reported from the General Hospital some five weeks after the original surgery to have a large incisional hernia.

The use of "pulley" sutures, either in mass closure of the wound or as a method of retention suturing to supplement layer closure, has resulted in almost uniformly bad results. A number of these cases have been reported from the General Hospitals to have developed large sloughs in the wound from strangulation and several cases have required secondary suture.

Laparotomy (Comment, contd)

The measures to be employed in the prevention of wound dehiscence must necessarily be multiple and they must begin when the incision is made. The trauma necessary to make and close an incision must be kept at a minimum. Gross soiling and contamination of the wound must be prevented if at all possible. The Halstedian principles of tissue handling were all designed to lesson wound reaction which in turn favors the uncomplicated healing of wounds. Failure to observe these principles contributes just as effectively toward the production of dehiscence as does the failure to have a good closure to safeguard against it.

Though we have placed great faith in a good mechanical closure of the wound, we have not underestimated the importance of certain physiological and chemical factors in sound wound healing. The erythrocyte count should be kept at, or above, four million, and the hemoglobin above 12 grams percent. Plasma 250 c.c. once or twice daily should be given as long as Wangensteen decompression is required. Vitamin C should be supplied parenterally in dosage of 200 mgm. daily until nourishment can can be taken by mouth and thereafter, 50 mgm. t.i.d. given orally. It is also well at the time of evacuation to leave the retention sutures in place and to provide additional abdominal support while in transit with a binder preferably of the Scultetus type.

PENICILLIN AND SULFONAMIDE THERAPY IN ABDOMINAL WOUNDS

Of the 3154 cases of abdominal wounds treated during 1944 and 1945, the records in 2410 instances were considered adequate for the purposes of this study. Cases which have been excluded are those in which exploration of the abdomen was negative, those that died on the operating table, and those in which the records were incomplete with reference to data on sulfonamide and penicillin therapy. In the total mortality of this group are all the cases in which death occurred from whatever cause during the period from the time of leaving the operating table to evacuation, a period usually of 10 days. Included also amongst these fatalities are those with multiple wounds.

In this group of 2410 cases, all received either penicillin or sulfonamide by some route. Previous to May 1944, sulfadiazine was used, and was given intravenously at 12 hour intervals in doses of two and one-half grams. After the beginning of May 1944 all patients routinely received 5,000 to 25,000 units of penicillin intramuscularly every three hours. The intraperitoneal administration of sulfanilamide, or penicillin, or both, depended on the judgment of the surgeon. When they were used in the peritoneal cavity, sulfanilamide in crystal form was given in doses of five to 10 grams and penicillin in doses of 50,000 units. No surgeon routinely gave either drug intraperitoneally. A few surgeons used either or both with fair consistency; most used them in selected cases, the most severely wounded; a few used them only occasionally by this route.

In the treatment of postoperative complications due to severe infection, there was more variation in the parenteral use of these drugs. Surgeons tended to switch drugs, to use both simultaneously, or to increase the dosage of penicillin. Data pertinent to the use of the drugs in these particular cases in the postoperative period are not available. In selected cases, such as those with potential or actual gas infections in associated wounds, or those with severe peritoneal soiling, the dose of parenteral penicillin was increased, or both penicillin and sulfadiazine were given simultaneously. Data suitable for statistical analysis concerning this are not available.

In all these patients there was some degree of peritoneal contamination ranging from only a minimal amount from the missile with associated body dirt and shreds of clothing, to the massive peritoneal soiling from a rent in the bowel. This in turn resulted in various degrees of peritoneal reaction or peritonitis.

In all these patients who came to autopsy some degree of peritonitis could be demonstrated. This obviously does not mean that they all died because of peritonitis. In such a series of patients in which multiple wounds are common it is difficult to determine at death exactly what

killed the patient. In many instances death cannot be attributed to one particular wound.

Since one of the purposes of this study was an attempt to compare the efficacy of sulfonamide and penicillin, and also various routes of administration, the criteria for attributing a death to peritonitis were strict. One would not expect these drugs to have an influence on the mortality of peritonitis in cases in which there was serious or fatal non-infectious associated pathology, or in cases who were moribund on admission and who did not live long enough for the drug to have any effect. For these reasons deaths were not attributed to peritonitis if they occurred in the first three days. Even those cases with severe peritonitis which died in the ward from aspiration or other accident, and those which had other serious disease, such as Bacillus coli empyema, were not counted as deaths from peritonitis. It is because of this strict exclusion that the mortality from peritonitis here is somewhat less than reported elsewhere in this work.

Peritonitis occurred in two rather well defined groups. The first group was composed of patients with massive peritoneal soiling, typically arising from leakage of the right colon. These patients were in profound shock which was very resistant to any therapy and they usually died within 24 to 48 hours, remaining in a state of shock the entire time. The second group ran the more common course of peritonitis as one usually conceives it. These patients developed distention, abdominal tenderness and either vomited or put out large quantities of fluid through the Levin tube. When death occurred it happened between the fourth and 11th postoperative days. Strangely enough these cases were relatively rare, accounting for only 42 deaths in 2410 cases, a mortality rate of 1.7%. This represents 7.3% of deaths in the series studied.

Except in this small "peritonitis" group, the peritoneum as seen at autopsy in cases in which death occurred from other causes usually presented a dull, only faintly pinkish grey appearance and contained perhaps 100 c.c. of dark sanguinous, odorless fluid. Adhesions were usually limited to the operative site. Active progressive peritonitis was not often seen.

TABLE I

Gross Mortality in Cases Reviewed

Abdominal Cases in 1944	1732	
Deaths		422 or 24.4%
Abdominal Cases in 1945	678	
Deaths		138 or 20.4%
TOTALS	2410	560 23.2%

Penicillin and Sulfonamide Therapy in Abdominal Wounds.

TABLE II

Mortality Due to Peritonitis and to Overwhelming Peritoneal Contamination With Shock

Abdominal Cases in 1944	1732		
Deaths Due to Peritonitis		32 or 1.8%	
Deaths Due to Overwhelming Peritoneal Contamination With Shock			58 or 3.4%
Abdominal Cases in 1945	678		
Deaths Due to Peritonitis		10 or 1.5%	
Deaths Due to Overwhelming Peritoneal Contamination With Shock			37 or 5.5%
TOTALS	2410	42 or 1.7%	95 or 3.5%

DISCUSSION

Unfortunately there are no adequate data concerning the incidence or morbidity of complications. Even in the matter of mortality it is difficult to make a comparison of the effectiveness of one drug as opposed to the other, or of the effectiveness of different routes of administration in this series. This is because the conditions differed under which the two drugs were given and because, as a rule, the intraperitoneal route was used in more serious cases. This is more fully explained elsewhere in this paper.

Further, there is no other series of cases in which no drug was used which can serve as a control to demonstrate the effect of either drug. Only in war surgery would one find a series of similar injuries occurring in a similar group of young healthy males. There are few injuries in civilian life which are comparable to those from high velocity shell, bomb fragments or from anti-personnel mines. In other series of war injuries such as those of World War I or of the Spanish War in which sulphonamides and penicillin were not available, other factors which influence mortality, such as unlimited supply of blood and plasma, naso-gastric siphonage, and widespread use of carbon dioxide absorbtion anesthesia were likewise not available.

TABLE III

Comparison of the Mortality in Two Groups of Patients,
One of Which Received Sulfonamides and the Other Penicillin

	Total Cases With Abdominal Wounds			Total Deaths in Patients With Abdominal Wounds						Deaths from Peritonitis in Abdominal Wounds						Deaths from Overwhelming Peritoneal Contamination With Shock					
				1944		1945		Total		1944		1945		Total		1944		1945		Total	
	'44	'45	Total	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Parenteral sulfadiazine and parenteral sulfadiazine plus intraperitoneal sulfanilamide	361	0	361	117	32.4	0	0	117	32.4	18	5.0	0	0	18	5.0	12	3.3	0	0	12	3.3
Parenteral penicillin and parenteral penicillin plus intraperitoneal penicillin	727	438	1165	158	21.7	97	16.6	255	22.0	2	0.3	4	0.9	6	0.5	18	2.8	10	2.3	28	2.4

TABLE IV

Comparison of the Mortality in Two Groups of Patients, One
of Which Received Drugs Intraperitoneally and Parenterally
and the Other Only Parenterally

	Total Cases With Abdominal Wounds			Total Deaths in Patients With Abdominal Wounds						Deaths from Peritonitis in Abdominal Wounds						Deaths from Overwhelming Peritoneal Contamination With Shock					
				1944		1945		Total		1944		1945		Total		1944		1945		Total	
	'44	'45	Total	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Parenteral and intraperitoneal therapy	1097	337	1424	291	26.5	83	24.3	374	26.3	27	2.5	8	2.4	35	2.5	49	4.5	29	8.6	78	5.5
2. Parenteral therapy	635	341	976	131	20.6	55	16.1	186	19.1	5	0.8	2	0.6	7	0.7	4	0.6	8	2.3	12	1.2

1. Intraperitoneal sulfanilamide with parenteral sulfadiazine or penicillin, or intraperitoneal penicillin with parenteral penicillin.
2. Either parenteral penicillin or sulfadiazine.

Penicillin and Sulfonamide Therapy in Abdominal Wounds. (Discussion, contd).

In Table III there is a statistical comparison of results in two groups of patients. One group received penicillin parenterally, or parenterally and intraperitoneally. The other group received sulfadiazine parenterally, or sulfadiazine parenterally and sulfanilamide intraperitoneally.

The mortality rate in the penicillin group is much lower than the sulfonamide group which were all treated in the early months of 1944. Some reduction of the mortality in the cases done in the latter part of 1944 and 1945 would be expected. The medical personnel were more experienced in handling battle casualties, blood banks were in use, and blood more freely available for transfusion in the latter cases. Further, it was the general impression that the patients arrived at the hospital in poorer condition during the early part of 1944. This was due to an unusual tactical situation and to the terrain, both of which impeded evacuation from the front to the hospitals, and to the bitterly cold, wet weather.

However, the most marked difference in the mortality was in the "peritonitis" group. Here, the mortality in the penicillin series is only 10% as great as that of the sulphonamide series, while in the "total mortality" and in the "overwhelming peritoneal contamination and Shock" groups the penicillin mortality is roughly 60% as great as the sulfonamide group mortality. We believe that this may be a significant difference.

It must be emphasized that these figures pertain to the result of drugs as used in these instances described, and not to the results of an ideal method of use. It is fully appreciated that giving sulfadiazine in two and one-half gr. doses at 12 hour intervals is not the best method of administering this drug. With large numbers of patients and limited personnel it was the only feasible method. The practical difficulties encountered in giving sulfonamide is a factor in favor of penicillin. While the former would require the full time service of at least one medical officer, the latter can be entrusted to an enlisted technician who simply goes around to inject all patients every three hours. It is also felt that intravenous sulfonamide may contribute to the oliguria and anuria in the severely shocked patients among whom this is a fairly common occurrence.

In examining the statistics of the two groups, one of which received only parenteral therapy and the other both parenteral and intraperitoneal therapy, it is seen that the mortality of the latter is much higher (Table IV). This is readily explained by the fact that the more severely wounded patients more often received both parenteral and intraperitoneal therapy. Because of the large number of variables, such as evacuation time, exposure to weather, various combinations of wounds, etc, it is impossible to pick out two groups of similar cases, one of which received intraperitoneal therapy, and one which did not, with enough cases in each to make a significant comparison.

SUMMARY AND CONCLUSIONS

What part penicillin and sulfonamides played in the low mortality due to peritonitis is difficult to determine. We believe they certainly played some beneficial part. However, it is impossible to separate statistically the effects of these drugs from the effects of good surgery and anesthesia, availability and use of large volumes of blood and plasma, and adequate ward care with careful attention to continuous gastric siphonage.

POSTOPERATIVE COMPLICATIONS IN ABDOMINAL CASES

The records of 3090 patients with abdominal wounds were reviewed to determine the incidence and nature of the postoperative complications.

In Table I there is a simple list of the postoperative complications as they were recorded excluding the thoracic ones. The latter are taken up in detail in Table II.

TABLE I

Recorded Postoperative Complications Other Than Pulmonary

Dehiscence of abdominal incision		36
Infection of abdominal incision		32
Urinary suppression		36
Fistula from gastro-intestinal tract		23
Small bowel	12	
"Fecal"	8	
Duodenal	2	
Gastric	1	
Gas infections (Total)		21
Abdominal	1	
Retroperitoneal	5	
Other	15	
Subphrenic abcess		15
Pelvic abcess		9
Intestinal obstruction		21
Thrombophlebitis and phlebothrombosis		5
Secondary hemorrhage		8
Intercostal artery	1	
Femoral artery -	1	
Gastric hemorrhage	6	
Urinary fistula		6
Fat embolism		4
Acute gastric dilation		3
Vesicorectal fistula		1
Parotitis, acute noncontageous		1
Orchitis, acute nonspecific		1
Encephalomalacia due to ligation of common corotid artery		1
Meningitis, secondary to spinal cord injury		1
Cerebral infarct		1
Anephylactic shock (due to "Amigen")		1
Cachexia due to ileostomy		1
Air embolism		1

We wish to emphasize that the true incidence of complications is much larger than recorded here. Many processes commonly regarded as complications occurred so frequently that they came to be regarded as normal occurrences and not as complications since no effort was made to make special note of them on the records. This was often true, for example, of mild atelectasis, mild or moderately severe infections of the operative incision, mild degrees of peritonitis, and hydropneumonthorax in the cases with associated intrathoracic wounds. However, it is believed that this study shows the comparative frequencies of many of the various complications.

SHOCK

Although found to be the most frequent principal cause of death, "shock" was not classified here as a true complication. It has been discussed as a separate entity in other papers (see pages 108 to 109) found to account for 62% of the total deaths.

INFECTIONS AND DEHISCENCE OF ABDOMINAL WOUNDS

The vast majority of the abdominal incisions had some degrees of infection, as the majority of the abdominal cases were contaminated. However, most of these infections were not clinically significant and they were recorded in only 32 instances.

There were 36 instances of dehiscence of the abdominal wound. The high prevalence of respiratory infections and infections of the wound were contributing causes. In the winter time when fresh vegatables were not available, avitaminesis probably played some part.

The subjects of wound dehiscence and infections are covered completely in another report (page 187).

PERITONITIS

All patients with an abdominal wound had some degree of peritonitis. It ranged in degree of severity from that which would be regarded as a peritonitis only from an academic view to the severe, overwhelming type which caused death within a few hours. It is impossible to draw a line where clinical peritonitis begins, hence no figures are given for the antemortem incidence of peritonitis. It did, however, account for 12% of the total deaths.

For further information, see the papers "Postoperative Care of the Seriously Wounded" (page 203) and "Penicillin and Sulfonamides in Abdominal Wounds" (page 197).

URINARY SUPPRESSION

This highly lethal complication was unforseen. This is fully discussed elsewhere (see page 758).

SUBPHRENIC AND PELVIC ABCESS

Subphrenic abcess was recorded in 15 instances and pelvic abcess in nine. The standard methods of management, i.e., early diagnosis followed by surgical incision and drainage, were employed in these cases.

Inasmuch as our patients were usually evacuated within 10 days, the true incidence was undoubtedly much higher.

OTHER COMPLICATIONS

Urinary infections were manifest only as a laboratory finding. Clinically they did not occur. The various other complications listed occurred so rarely as to require no comment. Some are covered in the discussion of other sections.

PULMONARY COMPLICATIONS

Table II is a list of the intrathoracic complications as they were recorded. The cases listed under "hydropneumothorax" include cases in which small amounts of blood, fluid and air were present singly or in combinations. This figure is obviously incorrect as practically all of the 965 abdominal cases with associated intrathoracic wounds had some blood, fluid, and air present postoperatively.

As to the various infectious pulmonary complications shown in Table II, although they are broken down into various categories, it is the general consensus of opinion that the vast majority of them represent cases of unrelieved atelectasis followed by infections.

Pulmonary infarction was recorded in 22 cases. On the average they occurred on the seventh postoperative day; the earliest occurred on the day of operation and the latest on the 22nd day; only 3 occurred after the 12th day. This is somewhat earlier than usually reported. It is suggested that in this series the origin of some of the emboli may have been in traumatized intra-abdominal veins.

It is interesting to note that the incidence of pulmonary infarction is somewhat higher in cases who did not have an associated chest wound.

Postoperative Complications in Abdominal Cases (Pulmonary Complications contd)

Infarction occurred in 0.8% of cases without an intrathoracic wound and in 0.52% of the abdominal cases with an associated intrathoracic wound.

Of the 22 cases 21 died. We are certain that nonfatal pulmonary emboli and infarcts of the lung occurred more than once. The difficulty of making an accurate diagnosis of mild or even moderate degrees of pulmonary infarction in patients who have other serious diseases of the abdomen, chest or both should be obvious.

TABLE II

Recorded Intrathoracic Complications in 3090 Abdominal Cases.

	965 Abd Cases With Assoc Thoracic Wounds			2125 Abd Cases Without Assoc Intrathoracic Wd		
	Lived	Died	Total	Lived	Died	Total
Empyema	16	9	25	2	2	4
Hydrothorax	77	9	86	5	0	5
Bronchopleural fistula	13	5	18	0	0	0
Pulmonary embolism	0	5	5	1	16	17
Atelectasis	12	11	23	32	5	37
Bronchopneumonia	6	6	12	20	19	39
Lobarpneumonia	0	2	2	0	5	5
"Consolidation"	2	4	6	4	4	8
"Wet lung"	1	3	4	5	4	9
"Pulmonary edema"	2	4	6	5	11	16
Bronchitis	1	1	2	0	1	1
Bile empyema	2	4	6	1	0	1
Aspiration of vomitus	0	1	1	2	5	7
Blast	1	1	2	1	3	4
Lung Abscess	0	0	0	0	2	2
Other	0	1	1	6	0	6
Totals	133	66	199	84	77	161

Total recorded complications ....199 + 161 = 360
Total deaths .... 66 + 77 = 143

Table III shows the effect of weather on the incidence of, and mortality occurring in selected pulmonary complications. It is to be noted that there was about a 40% increase in the incidence of these infections and that they were a little more fatal in the cold months than in the warm months.

Postoperative Complications in Abdominal Cases (Pulmonary Complications contd)

TABLE III

Effect of Weather on Pulmonary Complications *
Occurring in Abdominal Cases

	Cold Months	Warm Months
Total cases	1828	1262
No. pulmonary complications	112	55
Incidence rate	6.1%	4.3%
Deaths	56	22
Mortality rate	50%	40%

* Includes Bronchopneumonia, Lobarpneumonia, "Consolidation", "Wet lung" and Pulmonary edema of Table II.

Table IV is an analysis of abdominal cases for the purpose of determining the effect of associated thoracic wounds on the incidence and mortality of infectious pulmonary complications (empyema excluded).

Contrary to the expected result, it is seen that the incidence and mortality rate of pulmonary infection is about the same whether an intrathoracic wound is present or not

TABLE IV

Effect of an Associated Intrathoracic Wound on
Pulmonary Infections* Occurring in Abdominal Cases

	Wound of Abdomen Only	Wound of Abdomen and Chest
Total cases	2125	965
No. pulmonary infections	55	22
Incidence rate	2.6%	2.2%
Deaths	31	13
Mortality rate	56.3%	59.0%

* Includes Bronchopneumonia, Lobarpneumonia, "Consolidation", Bronchitis and Lung abscess of Table II.

In considering empyema alone it is found to occur 14 times as often in cases with an associated intrathoracic wound (see Table II), being recorded 25 times in the 965 cases with an associated chest wound and only four times in 2125 of the abdominal cases without an associated chest wound.

Postoperative Complications in Abdominal Cases (Pulmonary Complications contd)

Table V shows the effects of weather on associated intrathoracic wounds on the incidence of, and mortality in pulmonary infections occurring in abdominal cases. It is seen that the mortality rate for the pulmonary infections is definitely highest in cold months in patients with an associated intrathoracic wound.

The figures in the incidence rates are not very enlightening. While it is evident that for the simple abdominal cases there is a marked increase in the cold months it is not so for abdominal cases complicated with an intrathoracic wound. As previously shown in Table IV, it can be seen here again that an intrathoracic wound does not seem to increase the incidence or the mortality rate of pulmonary infection.

TABLE V

Effect of Weather and Presence of Associated Intrathoracic Wound on Selected Pulmonary Complications* in Abdominal Cases

	Abdomen Only		Abdomen and Chest	
	Cold Months	Warm Months	Cold Months	Warm Months
Total cases	1243	882	585	380
No. pulmonary infections	79	35	33	20
Incidence rate	6.3%	4.0%	5.6%	5.3%
Mortality rate	45.5%	34.3%	60.6%	50.0%

* Includes Bronchpneumonia, Lobarpneumonia, "Consolidation", "Wet lung" and "Pulmonary edema" of Table II.

Table VI shows the effects of the number of intra-abdominal organs injured; with increasing number of organs involved the incidence of pulmonary infection increased.

TABLE VI

Effect of the "Multiplicity Factor" on Incidence of Pulmonary Complications

No. Organs involved	1	2	3	4	5
No. Cases (total)	1416	897	322	83	13
No. cases developing infectious pulmonary complications	87	55	40	11	3
Incidence rate	6.1%	6.1%	12.7%	13.3%	23.1%

Postoperative Complications in Abdomina Cases (Pulmonary Complications contd)

In Table VII the infectious intrathoracic complications are analyzed for the effect of time lag. As demonstrated in the study on "Time Lag" (page 132 to 146), it is again evident that if one groups unselected dissimilar cases for analysis of the effect of time lag, that the other factors neutralize the effect to such an extent that the effect of time lag is hidden.

It is most emphatically against all clinical experience to hold in a given case that an increase in the time lag does not adversely effect the patient.

TABLE VII

Effect of Time Lag on Incidence of Selected Pulmonary Complications* and on the Mortality Rate in These Cases

Time Lag	0-6 hrs	7-12 hrs	13 or more hrs
Total number of abdominal cases	695	1509	886
No. developing pulmonary complications	55	75	55
Incidence rate	7.9%	4.3%	6.3%
Deaths	24	34	25
Mortality rate	43.6%	43.3%	45.5%

* Includes Bronchopneumonia, Lobarpneumonia, "Consolidation", "Wet lung" and "Pulmonary edema" of Table II.

CONCLUSIONS

1. The complications recorded in 3090 cases reviewed are tabulated and discussed.

2. The number of cases with complications in almost all instances are much too low and are not to be taken as the actual frequency of the various complications.

3. Weather during the "cold months" and multiplicity of abdominal organs injured increased the incidence of intrathoracic complications.

4. The intrathoracic wound does not increase the incidence or mortality of infectious pulmonary complications.

5. The effect of time cannot be demonstrated in studying groups of unselected dissimilar cases even if the groups are large.

WOUNDS OF THE ABDOMEN

Part III

Specific Viscus Injuries

WOUNDS OF THE STOMACH

(An Analysis of 416 Cases)

Wounds of the stomach are one of the deadliest of abdominal lesions produced in modern warfare, being exceeded in mortality only by wounds of the pancreas and duodenum. A study of the 416 wounds of the stomach treated during 1944 and 1945 indicates (1) that wounds of the stomach occur more frequently in war injuries than was formerly supposed, (2) that wounds of the stomach are complicated by injury to other abdominal viscera in 90% of the cases, and (3) that the mortality rate in stomach wounds is significantly higher than wounds of the colon, small intestine, liver, spleen, or genito-urinary tract. Various other data of interest in relation to incidence, diagnosis, shock, treatment, complications, and deaths in wounds of the stomach have been collected and analyzed. The resultant data and conclusions are presented.

GROSS STATISTICAL DATA

Incidence

The stomach was involved in 416 instances among 3154 abdominal and thoraco-abdominal wounds, an incidence of 13.2%. Table I gives the gross incidence and mortality figures in stomach wounds.

TABLE I

Incidence and Mortality

GROSS TOTAL			*UNCOMPLICATED CASES			*COMPLICATED CASES		
No. Cases	Incidence in 3154 Cases	Mortality Rate, Gross	No. Cases	Incidence of 416 Cases	Mortality	No. Cases	Incidence of 416 Cases	Mortality
416	13.2%	40.7%	42	10.1%	28.5%	374	89.9%	42.0%

* In this study, the term "uncomplicated" indicates that the stomach was the only abdominal viscus involved, while "complicated" indicates other abdmoninal visceral involvement. The term "associated injury" refers to extra-abdominal injury.

The figures 13.2% for gross incidence of stomach wounds in abdominal cases, and 89.9% for incidence of complicated injuries to the stomach are in marked variance with other sources of statistical information. Table II compares the incidence data reported from several sources.

Wounds of the Stomach (Gross Statistical Data contd)

TABLE II

Comparative Incidence of Stomach Wounds

Source	Total Abdominal Cases Reported	No. of Stomach Wounds	Incidence	No. of Complicated Stomach Wds	Incidence of Complicated Stomach Wds
World War I (1)	not given	144	7.0%	48	33.3%
Wallace (2)	965	82	8.5%	26	31.7%
Ogilvie (Lybian Campaigns)(3)	381	22	5.8%	11	50.0%
Jolly (Spanish Civil War (Republican))(4)	238	20	8.3%	not given	not given
Present Series	3154	416	13.2%	374	89.9%

Relative Incidence of Wounding of Stomach in Thoraco-Abdominal Wounds and Abdominal Wounds

Of 416 stomach wounds, 196 (47%) were produced by missiles traversing the diaphragm. There were 85 deaths among the 196 cases, the mortality rate in this group being 43.4%. The remaining 220 cases (53%) were wounded by projectiles entering or traversing the abdominal cavity only. Eighty-four deaths occurred in this group, a mortality rate of 38.2%. It is to be noted that the difference in mortality rate of the two groups is 5.2%. A number of records stated that a "violent chemical pleuritis" was seen in patients with stomach wounds in whom a laceration of the diaphragm existed. This may partially account for the difference in mortality noted above.

TIME LAG

It is a well established fact that for the individual case, time lag is of the utmost importance. Without the consideration of time lag in relation to other factors, such as multiplicity of injuries, amount of peritoneal contamination, and associtated injuries, time lag statistics are of little significance or value. (See "Time Lag", pages 132 through 147.) In this series, the wounds of the stomach were of such a relatively small number as compared with intestine, and uncomplicated stomach wounds so few, that extensive breakdown into the several factors was not of statistical significance. The time lag in relation to mortality rate is given in Table I (appendix), and shows nothing of statistical value.

SHOCK IN STOMACH WOUNDS

The correlation of the severity of shock in stomach wounds to mortality is shown in Table III.

Wounds of the Stomach (Shock in Stomach Wounds contd)

TABLE III

Relation of Shock to Mortality - Wounds of the Stomach - 404 Cases*

Degree of Shock on Admission	Cases	Deaths	Mortality Rate
No Shock or Incipient Shock	66	4	6%
Mild Shock	103	19	18%
Moderate Shock	106	50	47.1%
Severe Shock	129	98	76.0%

* Data not available on 12 cases for estimate of shock. Shock estimates based on blood pressure, clinical degree of shock, preoperative resuscitation therapy, and anesthesia records.

It is to be noted that an unusually high proportion of patients fall into the moderate and severe shock groups, and this can probably be explained, at least in part, by the spillage of acid gastric contents into the general peritoneal cavity. The phenomenon of shock following the acute perforation of a peptic ulcer is a familiar clinical entity. There seems to be little doubt that when the acid gastric contents are dumped into the peritoneal cavity, an almost immediate chemical peritonitis ensues, quickly productive of a shock-like state. Later a superimposed bacterial peritonitis occurs.

The anatomical location of the stomach, overlying the celiac axis area, the aorta, and the inferior vena cava and portal veins leads to a situation in which wounds are likely to be attended by considerable hemorrhage. Actually, however, of the patients seen at surgery, hemorrhage has not appeared to be more striking than hemorrhage from many other organs. The part hemorrhage plays in the production of shock in stomach wounds cannot be determined, but in the average case, hemorrhage often seems to be of secondary importance to peritoneal contamination.

Confirmatory evidence of the severity of shock in stomach wounds is indicated by the fact that death occurred on the operating table in 22, or 13% of all patients dying with stomach wounds. One hundred and fifteen, or 70% of the deaths occurred between the start of surgery and the end of the second postoperative day. Almost invariably, the recorded causes of death were "shock" or "shock and peritonitis".

CLINICAL DIAGNOSIS: SIGNS AND SYMPTOMS OF STOMACH WOUNDS

There are only two signs in preoperative diagnosis which point conclusively to a stomach wound: One, the emission of undigested food from a wound; the other, the observation of a perforation or laceration in a prolapsed stomach. Other signs and symptoms are merely indicative.

Wounds of the Stomach (Clinical Diagnosis; Signs and Symptoms of Stomach Wounds, contd)

The literature has repeatedly and repetitiously called attention to vomiting as a cardinal sign of stomach injury. In this series of cases, vomiting has been no more frequently associated with stomach wounds than any other abdominal injury, and is not, we believe, a reliable sympton. The presence of vomiting was noted only seven times in four cases of which it was bloody. A survey of the opinions and observations of the surgeons and resuscitation officers of this Group disclosed that no one was of the opinion that vomiting was an outstanding or significant feature.

Blood in the vomitus or in the aspirated gastric contents is a very suggestive sign, and one of the most reliable, it being recorded in 41 cases. The fact that swallowed blood from wounds of the head, neck, or lungs may give the same findings and lead to erroneous conclusions must be kept in mind. If these confusing factors can be ruled out, however, the sign is a valuable clue. The absence of blood in gastric contents, on the other hand, does not mean that the stomach is uninjured. Clear stomach contents were noted eight times in this series.

It is the opinion of this Group (an opinion carried out in practice) that no hesitation whatsoever need be felt over passing a Levin tube preoperatively in wounds of the stomach. On the contrary, every effort should be made to insert the tube not only as a dignostic measure, but also from a therapeutic standpoint. The accumulation of gas and fluid in a perforated stomach will only lead to increased leakage and more severe peritoneal contamination, and relief of this condition far outweighs any possible "contamination" introduced by the tube. Gastric dilatation and distention from fluid and gas is a common occurrence in abdominal wounds, and also may and does occur in stomach wounds.

The leakage of gas from the damaged stomach may be a valuable diagnostic sign, inasmuch as there may be produced a variety of interesting and at times comfusing clinical pictures. For example, subcutaneous emphysema of all degrees may be produced in the abdominal and chest wall; gas may actually bubble from the abdominal wound on expiration. In the event that the wound is of the thoraco-abdominal type, gas from the stomach may escape through the lacerated diaphragm into the pleural cavity, producing pneumothorax. A gas bubble lying free in the peritoneal cavity may be discovered on roentgenographic examination (noted six times in this series). At other times the surgeon, on opening the peritoneum, may be greeted by a somewhat disconcerting gush of air. These gas signs are often confusing since it may be difficult to determine whether the intra-abdominal gas is coming from the chest through a perforated diaphragm, or from the stomach. Only a careful exploration will determine the source of this free gas. Furthermore, a diagnostic problem may present itself in regard to anaerobic infections. It is often quite difficult to determine whether the crepitus and tissue discoloration are the results of an early anaerobic infection, or the results of the gas and acid leakage from a perforated stomach.

Wounds of the Stomach (Clinical Diagnosis; Signs and Symptoms of Stomach Wounds, contd)

The preoperative diagnosis of stomach wounds depends primarily on the visualization of the course of the missile, and applying accurate anatomical knowledge of the location of the organ. The entrance and exit wound in perforating injuries, and the entrance wound and localization of the missile by two-plane roentgenography will permit this visualization in the great majority of cases. The anatomical type of the stomach ("J" shaped, steer horn, etc.,) and the body position at time of wounding are complicating factors. The following case illustrates the influence of position: A Prisoner of War was admitted to a Field Hospital with an entrance wound of the left hip just above the head of the femur, and an exit wound of the right hip through the wing of the ilium. A low midline exploratory incision was made, which disclosed multiple perforation of the small bowel and sigmoid colon. In addition, at a distance of four inches above the upper end of the incision, a badly lacerated stomach was found. Undoubtedly, this man had been crouched over as only being under fire can make a man crouch, forcing his stomach into the lower abdomen.

PATHOLOGY OF STOMACH WOUNDS

Stomach wounds seen in warfare vary greatly. The wound may be a simple tangential laceration of the stomach wall without penetration into the lumen (16 such cases recorded in this series). The wound may be a trivial perforation, or it may be a laceration up to 20 cm in length. Finally, complete transection of the stomach may be produced by the violence of the trauma (five cases in this series). In general, a fair proportion of the wounds are made by small missiles which perforate one or both walls of the stomach in a perpendicular plane or at an obtuse angle. These perforations may result in little or no peritoneal contamination from gastric leakage, inasmuch as the gastric mucosa being redundant, tends to act as a valve. On the other hand, missiles entering the stomach wall at an acute angle may produce extensive lacerations regardless of the size of the projectile. It is safe to assume (confirmed by clinical observations) that a fair number of the simple, small perforations of the stomach result in little peritoneal contamination, and consequently less severe shock and mortality. On the other hand, perforating wounds may leak profusely. Lacerating wounds inevitably lead to severe peritoneal contamination. The resultant effect on mortality is demonstrated:

TABLE IV

Perforating and Lacerating Wounds of the Stomach

Type of Lesion	No. Cases	Deaths	Mortality Rate
Perforating	258	91	35%
Lacerating	117	71	60%

Wounds of the Stomach (Pathology of Stomach Wounds, contd)

It is recognized that larger missiles tend to produce lacerating wounds, and in general, more lethal wounds. This undoubtedly explains in part the difference in mortality.

UNCOMPLICATED STOMACH WOUNDS

Wounds of the stomach alone, without complicating wounds of other abdominal organs, occurred in 42 instances of the 416 cases, or an incidence of 10.1%. This incidence is remarkably lower than any previously reported (Table II shows the converse).

Uncomplicated stomach wounds carried a surprisingly high mortality rate (28.5%) and it would seem that this is one of the organs in which the multiplicity factor does not follow the general rule, i.e., the greater the number of organs injured, the higher the mortality rate (see Figure 32 and Table II appendix). Each of the 12 cases ending fatally was analyzed to see if some clue could be obtained as to why uncomplicated stomach wounds carried such a high mortality in this series. It was found that seven of the deaths occurred either on the day of operation or within the first two postoperative days, the cause of death falling in that group of cases classified as dying from "shock" and "shock and peritonitis". Two cases died the fourth and eighth postoperative days, respectively, of peritonitis, one died on the 14th postoperative day of secondary gastric hemorrhage, and one died on the 15th postoperative day of a gastric fistula and peritonitis. One case had no data regarding the cause of death. Mortality figures based on 42 cases are subject to considerable statistical error, but one is impressed by the large number of deaths occurring in the "shock" group of cases.

COMPLICATED STOMACH WOUNDS

This group of cases constitutes 90% of the stomach wounds. Table V shows the incidence and mortality rates of stomach wounds in which a single additional viscus complicates the stomach wound.

TABLE V

Stomach Wounds Complicated by Wounds of One Other Viscus

	No. Cases	No. Deaths	Mortality Rate
Stomach and Duodenum	2	0	0.0%
Stomach and Jejunum	16	4	25.0%
Stomach and Ileum	7	0	0.0%
Stomach and Colon	24	11	45.8%
Stomach and Liver	67	20	30.0%
Stomach and Spleen	42	8	19.0%
Stomach and Pancreas	6	1	17.0%
Stomach and Kidney	10	3	30.0%
Stomach and Major Vascular Injury	2	2	100.0%

Wounds of the Stomach (Complicated Stomach Wounds, contd)

The incidence of wounding of various viscera, and the mortality in complicated stomach wounds, without regard to number of viscera injured, is given in Figure 31 and Table III (appendix). The liver, as would be expected, was involved the greatest number of times, the spleen and colon being injured next most frequently, while the jejunum and kidney were wounded in a significant number of cases. Concomitant injury to the colon, in general, produced the highest mortality rate. Major vascular injuries complicating stomach wounds were almost universally fatal.

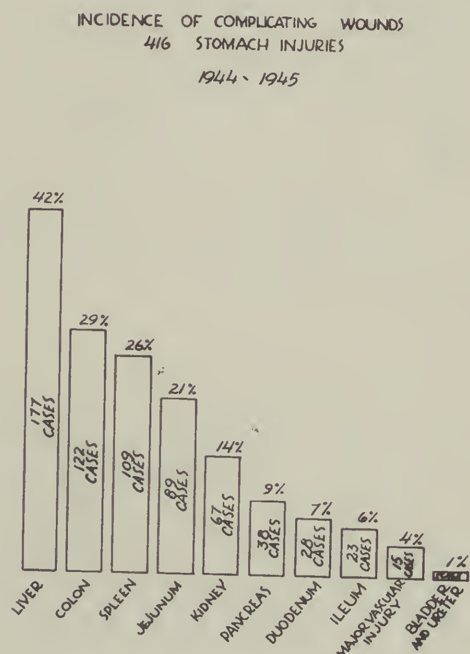

Figure 31 - Incidence of Complicating Injuries to Other Viscera in Stomach Wounds

Combinations of organ injury varied widely, and treatment was successful in certain combinations not previously recorded. For example, Bailey[5] states that no combination of wounds involving the stomach, small intestine and colon had been reported as surviving at the time his book was written. In the present group of cases, 24 instances of such wounding were reported, thirteen of which survived. Eleven of these cases

Wounds of the Stomach (Complicated Stomach Wounds, contd)

had, in addition, a liver wound. Table IV (appendix) shows the various combinations of organ injury encountered when the combination occurred five or more times.

THE "MULTIPLICITY FACTOR"

The "multiplicity factor" (see discussion of "Multiplicity Factor", page 112) has been found to be a more reliable index of prognosis than any other factor in abdominal wounds, but in wounds of the stomach this factor showed some inconsistency (Figure 32 text and Table II appendix). There is undoubtedly some margin of error of a statistical nature in the figure 28.5% mortality for wounds of the stomach alone, since the uncomplicated stomach group of 42 cases is not large enough to be conclusive. However, in spite of possible error, the mortality of stomach wounds alone seems to be of some significance.

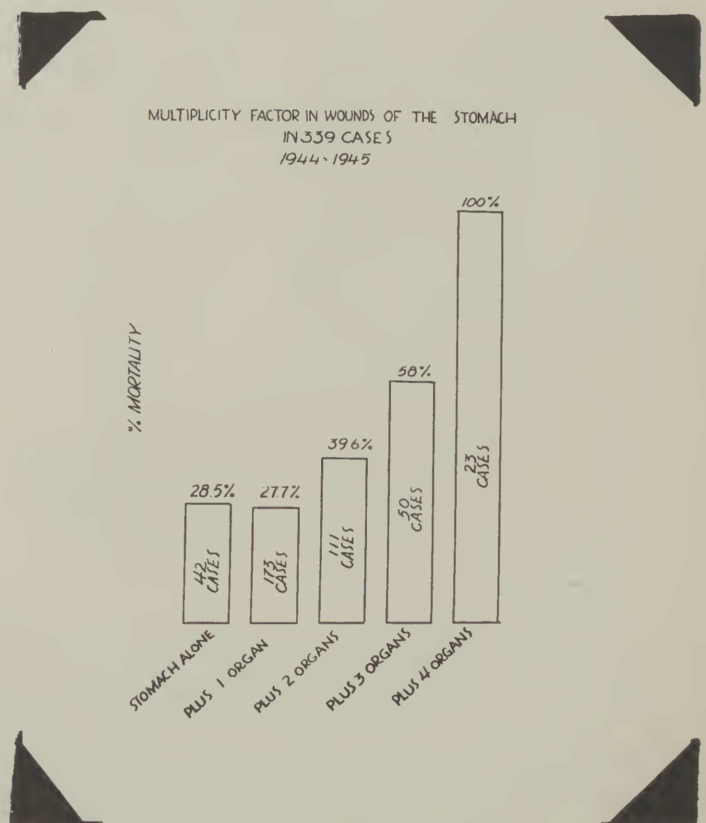

Figure 32 -"Multiplicity Factor" in Wounds of the Stomach

OPERATIVE TECHNIQUE

Surgical Approach

A transdiaphragmatic surgical approach to wounds of the fundus and body of the stomach greatly facilitates the repair of lesions in these areas. The surgeons of the Group used this type of approach in 60% of the 196 thoraco-abdominal wounds, and it became the incision of choice in selected cases. The transdiaphragmatic approach to stomach wounds in those cases having no diaphragm perforation was avoided; only in one such instance was it used. Details of incisions and surgical approaches are given in Table V, appendix. The importance of thoroughly examining the posterior wall of the stomach by incising the gastrocolic omentum cannot be stressed too strongly, and it was universally done by the surgeons of this Group. Both the anterior and posterior surfaces of the fundus are accessible transdiaphragmatically without the incision of peritoneal folds.

Procedures Used in Stomach Wounds

Simple suture of stomach lacerations and perforations was performed in 409 cases, even though the laceration was very extensive. Five cases showed complete transection of the stomach, and necessitated resection. Of these, two had end-to-end anastomosis, one dying; of the remaining three, some type of gastrojejunostomy (Polya or Hofmeister) was done, all dying.

There were two patients in whom perforations are known to have been overlooked. In one, a gastropleural fistula developed and death ensued. In the other, the overlooked perforations had closed spontaneously without apparent leakage. They were discovered in a patient dying of embolism and did not contribute to the fatality.

No particular type of suture or suture materials were used in the cases of this series, these matters being individualized through the preference of the surgeon. Purse string suture of the stomach, we believe, is to be avoided; the reasons are discussed below.

Suture in Relation to Postoperative Hemorrhage

There is one highly important technical point which has emerged from this study. Postoperative gastric hemorrhage of severe proportions occurred in six instances, and constituted the largest group of postoperative hemorrhage encountered in the entire abdominal series. In three of these cases, death ensued; two patients survived with conservative management; one recovered uneventfully after a secondary operation to control the hemorrhage. In all cases, the stomach wounds were simple perforations which were closed, in effect, with reinforced purse string sutures. This type of suture leads to a set of circumstances which are ideal for the subsequent development of postoperative hemorrhage, and the writer has seen this clearly demonstrated in two instances. A

purse-string sture of the stomach rarely, if ever, picks up the mucosa of the stomach. Subsequently, the edges of the mucosa slough, become endurated and retract, thereby exposing the blood vessels which traverse the submucosa, and producing a condition paralleling the pathological picture of an acute ulcer (Figure 33). Erosion of the previously scaled underlying vessels is likely to occur and hemorrhage follows. The case cited below is illustrative:

A soldier was admitted to a Field Hospital because of multiple shell fragment wounds, including a left thoraco-abdominal wound. His general condition was excellent. Left thoracotomy was performed and a transdiaphragmatic repair of a single perforation of the upper portion of the body of the stomach carried out. Convalescence was exceptionally smooth until the fifth postoperative day, at which time an unexplained rise in pulse rate was noted. Eight hours later it became obvious from signs and symptoms that the patient was hemorrhaging, though the location of the bleeding was not readily ascertainable. The nasogastric tube produced only a small amount of reddish brown fluid. Transfusions were given, but the response was only temporary. Consequently, after seven hours of observation, laparotomy was done. A distended stomach was found; it was completely filled with a clot estimated to contain 1500 c.c. of blood. This clot formed a perfect cast of the stomach. Gastrotomy was carried out, and after removal of the clot, the site of perforation previously sutured was inspected from the mucosal side. The surgeon's recorded discription is adequate: "A white indurated area is seen from which the mucosa is retracted. From the edges, in two places, are seen continuous but small streams of blood, one venous and the other arterial. This ulcer-like area, then, is the cause of all bleeding". The entire ulcer-like area was excised and closed. Uneventful recovery followed.

It is believed, on the basis of these and similar reports on other cases, that every effort must be made to approximate the gastric mucosa by suture in all stomach wounds. Small perforations must be enlarged by transverse incision in order to adequately expose and accurately suture the mucosal layer. The conclusion <u>that purse-string suture of stomach wounds in general is to be avoided is justified</u>.

Figure 33 - Appearance of Ulcer-like Lesion from Penetrating Wound of the Stomach

POSTOPERATIVE COMPLICATIONS OF STOMACH WOUNDS

Practically every stomach case that died within the first two postoperative days had the familiar picture designated under the generic term "shock". All these patients had varying degrees of peritonitis, extensive tissue damage, blood loss, disturbed pulmonary physiology, or the various combinations of these factors. Although strictly speaking, these were in fact postoperative complications, the picture that this group of cases presented was excluded from this discussion of postoperative complications. It is seen from Table VI (appendix) that pulmonary complications were by far the commonest. Pneumonia, empyema, and atelectasis accounted for approximately one-half of the serious complications.

Laparotomy, dehiscence, postoperative gastric hemorrhage, and peritonitis were next in order of frequency, while other complications seldom occurred.

Peritonitis recorded as such was the usual clinical type of peritonitis, and resulted in a high mortality rate (five out of six cases died).

ASSOCIATED INJURIES

Severe extra-abdominal injuries occurring in patients simultaneously with a stomach wound were present in approximately one fourth of the patients. The chest injuries of thoraco-abdominal stomach wounds are, strictly speaking, associated injuries, but their discussion is not included here although the presence of such a lesion apparently produced a 5% increase in mortality in the thoraco-abdominal group.

The evaluation of each associated injury and its influence on morbidity and mortality is almost impossible to arrive at unless one analyzes each case individually. Therefore, the associated injuries are simply tabulated in Table VII (appendix) no effort being made to assess their importance in individual cases. There were 43 major fractures, 41 major soft tissue injuries, nine major amputations, nine spinal cord lesions, four heart, and four brain wounds. The overall mortality of patients with associated injuries was not significantly different from that of patients with stomach and abdominal injuries alone, although the fallacy of this figure applied to the individual case is obvious.

ANALYSIS OF DEATHS

One hundred and sixty-nine deaths occurred in the forward hospital in the 416 patients with stomach wounds. Twenty-two, or 13% of deaths took place on the operating table, a somewhat higher proportion than the 10% occurring when no stomach wound existed. Seventy percent of the deaths occurred by the end of the second postoperative day, the cause of death almost invariably being ascribed to "shock", "shock and peritonitis", "shock and hemorrhage", or "overwhelming contamination". Anuria was recorded as the cause of death in 10 cases. In deaths occurring after the second postoperative day, peritonitis played a significant role in approximately 50%. Details of causes and day of death are recorded in Table VIII (appendix).

DISCUSSION

Three points of importance have emerged from this study of 416 wounds involving the stomach. They are:

Wounds of the Stomach (Discussion, contd)

1. Incidence

The incidence of stomach wounds is nearly twice as great as any previously reported incidence, and the number of complicated stomach wounds is nine times as great as uncomplicated stomach wounds. These figures merely confirm what can be deduced on a logical basis. As has been pointed out in a previous portion of this paper (pages 93 to 95) the incidence of wounding of any organ is almost directly proportional to the space it occupies. It follows, therefore, that the stomach, being a relatively large organ, should have a fairly high incidence of wounding, and that the incidence given is merely the incidence, not of wounding, but of patients seen at the hospital. We believe that our figure more nearly approaches the true incidence than lower figures, although the actual figure is undoubtedly higher yet. Similarly, the incidence of uncomplicated stomach wounds theoretically, should be quite low, inasmuch as the liver, spleen, colon, and kidneys almost completely invest the stomach. Our statistics confirm this. Here again, it would seem that the proportion of uncomplicated to complicated stomach wounds more nearly approaches the true incidence than other previously reported proportions.

2. Mortality

The data collected in this study point quite strongly to the fact that stomach wounds *per se* are one of the more serious types of wounds encountered in warfare. Some of the wounds are comparatively trivial matters, but on the other hand, the leakage of the acid gastric contents into the general peritoneal cavity when it does occur is a most shocking matter. Our data confirm this. Patients with stomach wounds, in general, not only exhibited a more severe degree of shock, but the mortality in this group of cases was significantly higher than in a comparable group of cases without stomach wounds. Moreover, the mortality rate of patients with lacerating wounds of the stomach was almost double that of patients having perforating wounds, it being reasonable to assume that *all* patients with lacerating wounds had peritoneal flooding with acid stomach contents, while only an indeterminate proportion of patients with perforating wounds had severe peritoneal contamination. Yet another confirmatory bit of evidence is shown in the high rate of death in uncomplicated stomach wounds. In general, the "multiplicity factor" shows consistency if one takes into account that the initial mortality of stomach wound alone is high.

The relative vascularity of the stomach and its environs played a part in the lethality of stomach wounds, but we believe that this is of secondary importance, basing our belief on the collected clinical observations of the surgeons in this Group, who noticed nothing particularly bloody about stomach wounds.

3. Postoperative Gastric Hemorrhage

Evidence is submitted to show that the incidence of postoperative secondary hemorrhage in stomach wounds is higher than secondary hemorrhage from any other viscus in first priority surgical patients. The cause of this phenomenon is discussed, and the conclusion drawn that purse-string suture of stomach perforations should not be done. Rather, the mucosa of the stomach should be exposed and accurately sutured.

SUMMARY AND CONCLUSIONS

1. An analysis of 416 wounds of the stomach has been made. The incidence of stomach wounds in 3154 abdominal injuries was 13.2%, of which only 10.1% were wounds of the stomach alone. In 47% of the cases the wounding missile traversed the pleural cavity; in 53% of the cases the wound was confined to the abdominal cavity alone.

2. There were 169 deaths in the forward surgical installations, a mortality rate of 40.7% among the 416 cases. Uncomplicated stomach wounds (42 cases) had a mortality rate of 28.5%.

3. Statistical and clinical data are presented on shock, pathology, operative technique, associated injuries, postoperative complications, and mortality; these various subjects are discussed. The cause and prevention of postoperative secondary hemorrhage from the stomach was presented.

4. Evidence was submitted to show that stomach wounds *per se* are one of the more serious of abdominal wounds occurring in warfare.

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3. Ogilvie, W. H. "Abdominal Wounds in the Western Desert", Surg, Gyn, and Obst, Vol 78, No. 3, March 1944, pages 225-238.

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Wounds of the Stomach (contd)

APPENDIX OF STATISTICAL TABLES

TABLE I

Time Lag and Mortality

Hours Lag	No. Cases	Deaths	Mortality Rate
0 - 6	121	47	40%
6 - 12	179	67	37%
12 - 18	65	30	46%
18 - 24	20	6	30%
24	17	7	41%

TABLE II

Multiplicity Factor in Stomach Wounds

	No. Cases	Deaths	Mortality
Stomach wounded alone	42	12	28.5%
Stomach wounded and one other wounded viscus	173	48	27.7%
Stomach wounded and two other wounded viscera	111	44	39.6%
Stomach wounded and three other wounded viscera	50	29	58.0%
Stomach wounded and four or more wounded viscera	23	23	100.0%
Stomach wounded and major vascular and other viscera	15	14	94.3%

Wounds of the Stomach (Appendix of Statistical Tables, contd)

TABLE III

Frequency of Injury of Other Abdominal Viscera
(in 416 Cases of Stomach Wounds) and the Mortality*

	No. Cases	Incidence	Deaths	Mortality
Duodenum	28	7%	18	64%
Jejunum	87	21%	32	37%
Ileum	23	5%	12	52%
Colon	122	29%	68	56%
Liver	177	42%	82	46%
Spleen	109	26%	42	39%
Pancreas	38	9%	21	55%
Kidney	67	14%	47	70%
Ureter	3	1%	2	66%
Bladder	2	1%	1	50%
Major Vascular Lesion	15	4%	14	94%

* Multiple Organs Involved

TABLE IV

Wounds of the Stomach combinations of Organs
Occurring in More than 5 Instances

	Cases	Deaths
Stomach alone	42	12
Stomach and Jejunum	16	4
Stomach, Jejunum, and Liver	9	3
Stomach, Jejunum and Kidney	6	2
Stomach, Spleen, and Kidney	6	2
Stomach, Jejunum, and Colon	13	4
Stomach, Jejunum, Colon, and Liver	11	5
Stomach and Ileum	7	0
Stomach and Colon	24	11
Stomach, Colon, and Liver	18	9
Stomach, Colon, and Spleen	6	2
Stomach, Colon, and Kidney	5	5
Stomach, Colon, Liver, and Spleen	5	2
Stomach and Liver	67	20
Stomach, Liver, and Spleen	17	5
Stomach, Liver, and Pancreas	5	1
Stomach and Spleen	42	8

Wounds of the Stomach (Appendix of Statistical Tables, contd)

TABLE V

Surgical Incisions and Approaches

Laparotomies	293
Thoracotomies	95
Thoracolaparotomies	6
Combined Laparotomy and Thoracotomy	18
Not Recorded	4
Total	416
Percent Thoracotomies	33%

TABLE VI

Frequency of Postoperative Complications
in 416 Stomach Wounds*

Complication	No. Cases
Pneumonia	12
Empyema	11
Dehiscence	8
Ateleclesis	6
Postoperative Hemorrhage	6
Peritonitis	5
Gastric Fistula	2
Intestinal Obstruction	5
Malaria	2
Anaerobic Infection	1
Heart Disease	1
Abscesses	
Subphrenic	2
Pelvic	3
Retroperitoneal	2
Incisional	6
Intra-abdominal	2

* Data confined to cases in which diagnosis made clinically before evacuation or death, and does not include post-mortem diagnoses.

Wounds of the Stomach (Appendix of Statistical Tables, contd)

TABLE VII

Associated Injuries - 416 Stomach Wounds

Major Fractures	43
Major Amputations	9
Spinal Cord Injuries	9
Heart Injuries	4
Brain Injuries	4
Major Soft Tissue Injuries	41

TABLE VIII

Causes and Time of Death, 169 Stomach Cases

	No. Deaths		Rate
Deaths on Operating Table	22		13%
Shock		13	
Shock and Peritonitis		1	
Shock and Hemorrhage		5	
Shock and Gas Gangrene		1	
Shock and Atelectasis		1	
Heart Lesion		1	
Deaths and Causes through 2nd Postoperative Day			
Shock		43	
Shock and Peritonitis		28	
Peritonitis (Overwhelming)		9	
Shock and Anaerobic Infection		2	
Shock and Atelectasis		3	
Shock and Hemorrhage		4	
Pulmonary Embolism		1	
Pneumonia and Peritonitis		2	
Intestinal Fistula and Peritonitis		1	
Died from start of operation through 2nd postoperative day	115		70%
Deaths and Causes after 2nd Postoperative Day	54		30%
Pneumonia		6	
Pneumothorax and Pleurisy		3	
Pneumonia, Empyema or Pleurisy and Peritonitis		12	
Peritonitis and Shock (all 3rd P.O. Day)		8	
Peritonitis		6	
Anuria		10	
Hemorrhage, Secondary		3	
Intestinal or Gastric Fistula		2	
Brain Injury		1	
Unknown		3	

Wounds of the Stomach (Appendix of Statistical Tables, contd)

TABLE IX

Mortality in 416 Stomach Wounds in Relation
to Type of Viscera Injured

Type	No. Cases	Deaths	Mortality
Stomach and Solid Viscera	168	47	27.9%
Stomach and Hollow Viscera	69	21	30.5%
Stomach and Both Solid and Hollow *	118	71	60.2%

* The high mortality rate in this group obviously reflects the effect of the "multiplicity factor".

DUODENAL INJURIES

Injuries to the duodenum occur infrequently, and it is a distinct rarity that the duodenum alone is damaged. In World War I, there were 10 instances of duodenal injury comprising 6% of all small bowel involvement. The mortality for these 10 cases was 80%. The statement is made in the general surgical section of the "Medical History of World War I", that multiple lesions are usually encountered in duodenal injury, the average expected is four to six.

Jarvis, in his analysis of the abdominal wounds handled by this Group in 1943, reports nine cases of duodenal injury with seven deaths. In two cases, the duodenal lesion was missed at operation and in one of these the missed perforation was the cause of death. These nine cases were marked by the multiplicity of organs involved. In three of the seven deaths reported, the pancreas was involved, in one the vena cava, and in another the superior mesenteric artery.

For the year 1944 and the active part of 1945, there have been 118 instances of duodenal injury encountered by this Group, and these 118 cases are the basis of this study. Three thousand one hundred and fifty-four abdominal operations were performed in this period, and duodenal injury was present in 3.74% of the cases (see Table I). Of the 1286 instances of small bowel injury, the duodenum comprises 9.2% of the cases.

TABLE I

Incidence and Mortality

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. Cases	Incidence in 3154 Cases	Mortality Rate (gross)	No. Cases	Incidence of Cases	Mortality	No. Cases	Incidence	Mortality
118	3.74%	55.9%	2	1.6%	0	116	98.4%	56.9%

MORTALITY

Mortality in this series is computed upon the basis of cases known to have died in the installation in which the initial surgery was done. In the 118 cases, 66 deaths occurred within the first 10 days, a mortality rate of 55.9%. There are three instances in which death probably occurred within the first ten days, but the records are incomplete.

The site of the wound of entry is fairly consistent in duodenal injury. The missile entered the right side of the trunk, either front or back, in 98 or 83% of the 118 cases. Twenty per cent of all wounds were perforating in type. As will be shown later in the discussion of

Duodenal Injuries (Mortality contd)

complicating injuries, there is a wound pattern in which duodenal injury may be reasonably expected and sought for. Figure 34 illustrates the approximate area of penetration of the missile in the duodenal injuries of this series and the frequency in actual numbers.

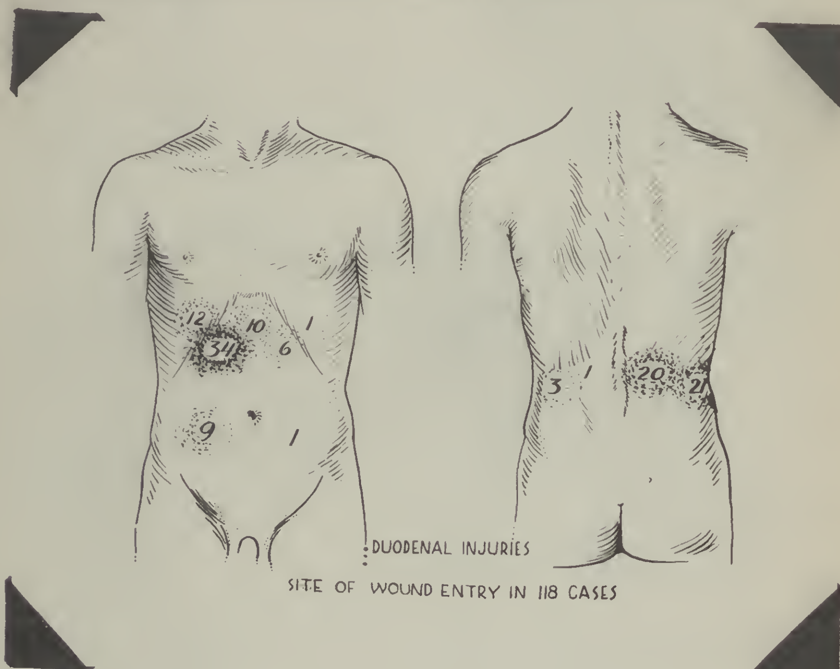


Figure 34 - Duodenal Injuries - Site of Wound Entry in 118 Cases.

There was one case of duodenal injury without penetration. The patient had a large gutter wound across the epigastrium with omentum herniated through the wound. No wound of exit was present and a foreign body could not be demonstrated by X-ray. It was felt by the operator that the stellate lacerations of the liver and second portion of the duodenum were due to blast.

SHOCK RECORD

The shock record upon admission to the hospital is constant in that the patients who subsequently died were in the main in a more severe state of shock than those that recovered. The classification of shock is taken from the records just as recorded.

Duodenal Injuries (Shock Record contd)

TABLE II

Degree of Shock

Degree of Shock	Lived	Died
None	14	6
Mild	12	3
Moderate	12	8
Severe	10	49

In four instances, the degree of shock was not recorded. Of the nine cases of vena cava laceration, one was not in shock, four in only moderate shock, and four in severe shock.

CAUSE OF DEATH

Shock and hemorrhage was the recorded cause of death in thirty-nine or 59.5% of the deaths. Forty-seven or 71% of the deaths occurred in the first three postoperative days. Two of the deaths resulting from peritonitis were due to injuries overlooked at operation, one a laceration of the common duct, the other a perforation of the third portion of the duodenum.

TABLE III

Day of Death and Cause

	Day of Death				
Cause of Death	At Operation	First 24 hrs	24 hrs to 72 hrs	3 to 10 days	Totals
Shock and hemorrhage	5	25	8	1	39
Pneumonia			2	7	9
Anuria			2	6	8
Transfusion reaction			2		2
Pulmonary embolism			1		1
Peritonitis				3	3
No record			2	2	4

COMPLICATING INJURIES

Multiple complicating lesions are usual in duodenal injuries. There were only two cases of damage to the duodenum alone in this series of 118, an incidence of 1.6%, and both survived.

Duodenal Injuries (Complicating Injuries contd)

In Table IV are shown the complicating lesions in addition to the duodenal injury in actual numbers. These figures are misleading in that in many instances there are multiple lesions to one organ which are recorded in the table as one; it does not take into account the vascular injuries, and further, the severity of the damage to one organ cannot be shown.

TABLE IV

Frequency of Complicating Injuries

No. of organs injured in addition to duodenum	Lived	Died	Mortality
1	12	15	55.5%
2	25	20	44.4%
3	7	14	66.6%
4	5	15	75.0%
5	1	1	50.0% ?

Not included in Table IV were the two cases of duodenal injury alone, and one of duodenum complicated by a portal vein laceration. It is seen that with three complicating injuries, the mortality is doubled and with four it is tripled. The one case recorded as living with five complicating lesions probably died as he was left moribund on the fourth postoperative day with a holding company.

In Table V is shown the greater number of organ resections required in those patients who subsequently died.

TABLE V

Organ Resections

Operation	Lived	Died
Splenectomy	1	4
Cholecystectomy	2	6
Nephrectomy	9	12
Right Colectomy	2	7
Resection of small bowel	4	9
Gastrojejunostomy	0	4

Vascular injuries are not an infrequent complicating wound in injuries to the duodenum. In this series of 118, there were nine, or 7.6% instances of vena cava laceration with eight deaths. There were two cases of portal vein laceration, two of the pancreaticoduodenal artery, and one each of the hepatic and right spermatic artery. All of these cases died.

Duodenal Injuries (Complicating Injuries contd)

In Table VI are listed the organs most frequently complicating duodenal injury, and the percentage frequency of their involvement. It may be seen from this chart, that there is a fairly constant wound pattern when the duodenum is injured. If, for example, there is a wound of the right upper quadrant that has involved the right kidney, liver, and right colon, an injury to the duodenum is quite likely.

TABLE VI

Incidence of Complicating Injuries
to Other Viscera

	No. of times injured	
Liver	69	58.4%
Colon	59	50.0%
Right Kidney	37	31.3%
Small Bowel	36	30.5%
Stomach	21	16.1%
Gall Bladder	17	14.4%
Pancreas	9	7.6%
Vena Cava	9	7.6%
Portal Vein	2	1.8%

The pancreas was involved in 7.6% of the cases in this series. Of the nine cases with pancreatic involvement, eight died. There was only one case in which the pancreatic head was damaged to the extent of severing the duct. The gall bladder was injured 17 times in this series, an incidence of 14.4%.

ASSOCIATED INJURIES

There were 15 of the 118 cases of duodenal involvement with an associated chest injury. This varied in severity from a simple perforation of the diaphragm to severe laceration or contusion of the lung. Of the 15 cases with associated chest damage, 11 died.

It is not within the scope of this paper to discuss shock, but it is shown that vascular injuries with concomitant hemorrhage played an important role in influencing mortality, and chest injuries with disturbance of cardiorespiratory physiology may have contributed to fatalities.

DUODENAL DAMAGE

Severe damage to the duodenum per se is not frequent. In only four instances was the damage severe enough to require a short-circuiting procedure. Of the four gastrojejunostomies done, all died.

Duodenal Injuries (Duodenal Damage contd)

In only one instance was the ampulla of Vater damaged, and there was only one of common duct injury. In no case was it necessary to perform a common duct short-circuit.

Table VII lists the site and type of injuries to the duodenum.

TABLE VII

Site and Type of Duodenal Injury

Site	Transection	Perforation	Laceration
First portion	7	12	8
Second portion	7	34	14
Third portion	1	6	8
Junction of first and second		2	4
Junction of second and third	1	2	2
Duodeno-jejunal junction	4		
Totals	20	56	36

In six cases, the type and location were not recorded.

COMPLICATIONS OF DUODENAL REPAIR

In most instances, lacerations and perforations of the duodenum were repaired as any small bowel laceration and technique varied but little among the individual surgeons. Transections of the duodenum were repaired by end to end anastomosis with running atraumatic chromic suture in most instances reinforced with black silk or cotton. In almost every case, the site of the repair was drained and universally when complicating pancreatic or liver wounds occurred. In most instances, the peritoneum was closed over the wound. In three cases where gastrojejunostomy was done, the duodenum was badly damaged and the proximal end was inverted, but none of these lived long enough to develop any possible complications.

There are two known duodenal fistulae that developed in the first priority hospital. Both of these were transections of the duodenum with an end to end anastomosis. Both developed on the sixth postoperative day. There is an additional case that probably developed a duodenal fistula. The record was not complete, but it had been noted on the sixth postoperative day that a clear irritating discharge was draining through the operative wound, and it was the opinion of the observer that a duodenal fistula had developed. This case was a simple laceration of the second portion of the duodenum, repaired by one row of running atraumatic chromic catgut reinforced with black silk sutures.

Duodenal Injuries (Complications of Duodenal Repair contd)

There was one case that probably had a duodenal blow-out, but the necropsy was not done. It was the opinion of the officer who saw him at death, that the duodenal suture had not held. The patient had had a through and through perforation of the uppor pole of the right kidney that was drained, and a through and through perforation of the second portion of the duodenum that had been closed with two layers of running atraumatic chromic suture. On the seventh postoperative day, he became markedly distended, and developed severe epigastric pain and expired in eight hours following the onset of these symptoms.

DIAGNOSIS OF DUODENAL INJURY

The preoperative diagnosis of a duodenal injury has no essential differences from that of any intra-abdominal injury. At operation, it was the practice of surgeons of this Group to always reflect the right colon and duodenum where there was any suspicion of a duodenal injury. The increasing consciousness of this possibility is shown in that of nine cases of duodenal injury handled by this Group in 1943, there were two perforations of the duodenum overlooked. In the one hundred and eighteen cases in this series done in 1944-45, there is only one case of an overlooked duodenal injury. Too much stress cannot be placed upon the advisability of thorough exploration of the duodenum in cases where there is any possibility that the missile perforated the retroperitoneal space behind the right colon, and this can only be done by reflecting the right colon.

DISCUSSION

It is seen that 98.4% of duodenal injuries have complicating lesions. The most frequent organs involved in order were liver, colon, and right kidney. In 83% of the cases, the missile entered either right lumbar area or right abdomen. With these facts in mind it may be reasonably deduced that a missile entering the right side, front or back, and injuring the liver, colon, and right kidney, has a very strong probability of also injuring the duodenum. It is again emphasized that it was the practice of surgeons in this Group to routinely reflect the right colon and examine the duodenum thoroughly in any case possessing the wounds as described above and also in any case presenting the probability of a duodenal injury.

Incidence of injury to particular portions of the duodenum was out of proportion to the mass of duodenum and its protection by bony structures such as the vertebrae. In 46.6% of this series, the second portion was injured, the first in 22.8%, and the third in 12.7%. In many of the cases of injury to the first portion of the duodenum, there was a continuous lesion with the pylorus and similarly in the third portion a continuous lesion of the jejunum. It is surmised that many injuries to the first portion of the duodenum do not survive to reach operation because of its close relationship with the vena cava, hepatic artery, and portal vein and again similarly with the third portion of the duo-

Duodenal Injuries (Discussion contd)

denum with its close relationship with the aorta, vena cava, and mesenteric vessels.

Twenty instances of duodenal transection were encountered in this series. The usual repair was by end to end anastomosis with a double layer of chromic catgut reinforced with interrupted black silk. Six of these transections lived through the sixth postoperative day and two of the six developed a duodenal fistula on the sixth day. The frequency of this complication can only be indicated by this small series but it aids to emphasize the necessity of drainage to a repaired duodenal injury.

SUMMARY AND CONCLUSIONS

1. Injuries to the duodenum are infrequent in abdominal wounds, and very rarely is the duodenum alone involved.

2. In abdominal wounds with duodenal injury, the mortality was 55.9% in 118 cases.

3. In this series, the site of the entry wound was in the right trunk in 83% of the cases.

4. Severe shock was usually present preoperatively in this series.

5. Multiple complicating injuries are usual in duodenal injury. Vascular injuries are not infrequent.

6. It was found that 12.7% of the 118 cases had an associated chest injury.

7. In only four cases of this series was the damage severe enough to require a short-circuiting procedure. There was only one case of injury of the Ampulla of Vater, and in no instance was a common duct short circuit required.

8. There were 20 transections of the duodenum in this series with the development of fistula in two. However, most transections died within the first three days. Six transections of the duodenum lived through the sixth postoperative day. Of these, two developed fistula. There is a strong indication of a high incidence of fistula development in the transected duodenum.

9. It is the practice of the surgeons in this Group to routinely reflect the right colon in injuries where there is any reason to suspect a perforation of the duodenum.

WAR INJURIES OF THE SMALL INTESTINE

The small intestine is frequently injured in wounds of the abdomen. Among 3532 patients with abdominal and thoraco-abdominal injury there were 1287 or 36.4% who suffered injury to the small bowel. A minor fraction of the total cases, comprising those treated in 1942 and 1943, has been previously reported, by Lowry and Lowry[1], and Jarvis[2]. Except for the computation of incidence and gross mortality rates, these cases are not included in this report (Tables I and II, Appendix).

From 1 January 1944 until the cessation of hostilities in Europe, there were 3154 cases with abdominal injuries treated by surgeons of this organization (Table I).

TABLE I

Gross Incidence and Mortality Rates, 1168 Small Intestine Injuries. (Exclusive of Duodenum) 1944-1945

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. Cases	Incidence in 3154 Cases	Mortality Rate **	No. Cases	Incidence	Mortality	No. Cases	Incidence	Mortality
1168	37%*	29.5%	353	30.2%	13.9%	815	69.8%	36.3%

*Incidence of small bowel wounds including duodenum in A.E.F. World War I, was 22%.[3]

**Mortality of small bowel wounds, World War I, was between 70% and 80%.[4]

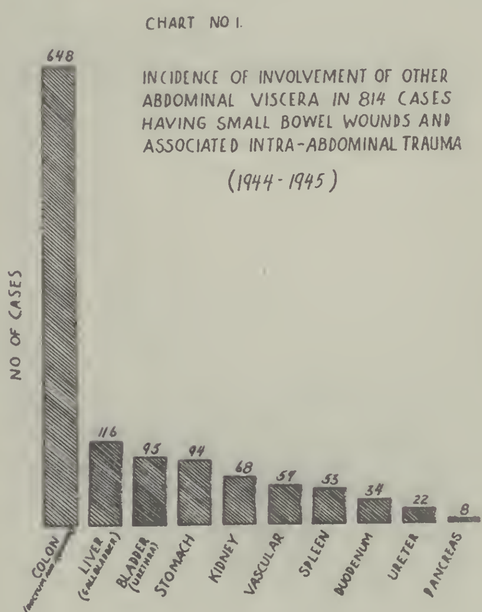
Small intestinal injury was present in 1168 (37%) of these cases, and this group forms the basis of the present study. All cases are included which were treated by members of the Group. A number of patients in this series died during surgery and several others expired during the induction of anesthesia*. Inclusion is made of those having injury to the bowel wall without penetration of the lumen. No exclusion has been made of civilian wounded, nor on the basis of age; however, civilians and persons in the extreme age groups form only a small fraction of the total cases.

Six cases of non-penetrating trauma to the abdomen are included; all were due to vehicle accidents and sustained rupture of the small intestine. One patient is included who stated that he was violently impaled on a small tree stump by the blast from an exploding shell, and who sustained a severe transfixing thoraco-abdominal wound. With

*A total of 28 deaths on the operating table occurred in this series.

the exception of these seven cases, all wounds were caused by high explosive fragments or small arms missiles. There were no bayonet nor stab wounds.

In analyzing uncomplicated small intestinal wounds, we have regarded the bowel in the light of its anatomical subdivisions into jejunum and ileum. This distinction proved impractical in the study of complicated cases, and in this group the intestine has been regarded for statistical purposes as a single organ. The duodenum is not included in this survey. In thisstudy, the term "complicating wound" is reserved for wounds to other abdominal organs or major vascular trunks, and "associated wound" denotes extra-abdominal pathology. (Figure 35)



Frequency of Complicating Injury to Other Viscera

Figure 35

War Injuries of the Small Intestine

THE INCIDENCE AND MORTALITY OF SMALL INTESTINAL WAR INJURIES

As previously stated, 37% of all abdominal cases treated in 1944 and 1945 had small intestinal wounds. Of these, 345 or 29.5% died. (Table I). The great majority of these deaths appears to have been due to complicating injuries. Among 815 complicated cases there were 296 deaths, a mortality of 36.3%. On the other hand, there were 353 cases in the uncomplicated group with 49 deaths and a mortality of 13.9%. These calculations have been made without regard for associated wounds to the thorax, head and neck, or extremities. These figures are in agreement with the observation that the fatality of abdominal wounds is usually proportional to the number of viscera involved.

THE NATURE OF WOUNDS TO THE SMALL INTESTINE

It will require no imagination by one acquainted with the engines of modern warfare to realize that the varieties of trauma they produce are all-inclusive. Lesions seen in the small intestine varied from pinpoint perforations and small contusions to extreme maceration and destruction of the greater part of the bowel. For convenience of consideration, types of trauma are grouped in three main classifications: injury to the wall only, perforating injury, and injury to the mesentery. There have been wide extremes of severity in each of these groups, and in the usual case two or more of them were seen in combination. Traumatic evisceration and the state of the peritoneum are separately considered in this section.

Trauma To The Wall Of The Bowel.

Trauma to the wall of the bowel includes contusions and serosal or sero-muscular lacerations which do not perforate the mucosa. These have been the least frequently seen types of injury (Table III, Appendix). Contusions of the bowel wall were seldom more than 2 cm. in diameter, and varied in appearance from a slight ecchymosis to a circumscribed area of gangrene. A contusion of the bowel wall implies by its very nature that the missile which caused it had reached the end of its flight and was traveling at low velocity. Impact against the intestine was sufficient to stop it, and such missiles have not infrequently been found free in the peritoneal cavity.

Lacerations of the outer layers of the intestinal wall are caused by tangential impact and carry no implications as to the velocity of the missile. Such trauma has usually been seen in association with perforation into the lumen in other portions of the bowel. Lacerations theoretically may be of any length, but they have been rarely seen of more than 2 cm. without perforation, and some were the merest breaks

War Injuries of the Small Intestine (Trauma to the Wall of the Bowel, cont'd).

in the serosa. There were usually evidences of contusion about the margin of these wounds, and such laceration-contusions were considered potential sites of future perforation.

Perforating Trauma of the Bowel.

By far the commonest injury to the small intestine was in the form of perforation into the lumen. Reference to Table III,(Appendix) will show that perforations were present in nearly every case, and that multiplicity was the rule, with an average of approximately four perforations per case. The individual lesions varied from the tiniest of holes to gashes extending for six inches or more. Small holes were usually caused by the very small fragments into which thin-walled projectiles (e.g. mortar bombs, certain anti-personnel aerial bombs) burst on explosion. Occasionally small perforations were apparently caused by in-driven fragments of bone, particularly in cases in which the missile had entered the abdomen through the ilium. Shell fragments (and mortar fragments at close range) and bullets usually caused large perforations, though rifle bullet wounds have been seen in which the missile had caused remarkably small holes. In general, it has been apparent that the size and shape of the rent in the bowel were determined by the corresponding characteristics of the missile, and by its velocity and direction of flight. Through-and through perforations and complete transection of the intestine were both frequent.

In most perforations of any size, the findings were usually similar. The tissues at the edges were contused and ecchymotic, the margins were jagged, and the mucosa pouted from the wound. Bleeding from the wall of the intestine was at times free, and sizeable quantities of blood have been seen in the peritoneal cavity when the bowel wall was the only source of hemorrhage. Small holes were on occasion nearly completely sealed off by the pouting mucosa and gave rise to a minimum of soiling. In such instances, bluish discoloration of the bowel from intra-luminal bleeding was sometimes present. Less commonly, blood and intestinal contents were extensively spilled from a small perforation (Case 1, Appendix).

Combined injuries to the bowel were usually found in close proximity, and the damage was commonly confined to a segment one or two feet in length or less. However in instances where the missile had traversed major diameters of the abdomen, one occasionally found scattered perforations along the intestine at wide intervals. Rarely, isolated perforations were found at a considerable distance from the major trauma. It was always necessary to examine the entire length of the bowel for injury.

War Injuries of the Small Intestine

Injuries to the Mesentery.

The mesentery was traumatized both at a distance from the bowel and at the attachment. The injuries varied from small hematomata or peritoneal lacerations to rents across the mesentery to its very root. In transections of the bowel and in perforations involving the mesenteric border, some amount of damage to the adjacent mesentery was nearly always present. This damage usually did not complicate the necessary repair or resection of the bowel. Active bleeding was seen, but frequently it had ceased.

Perforations of the mesentery other than those adjacent to injuries of the bowel were frequent. These were usually simple through-and-through holes, sometimes with associated hematoma. In the majority there was no indication that a vessel of great consequence had been involved. The incidence of mesenteric damage of such extent as to necessitate intestinal resection was remarkably low. In this series there were only 30 cases in which resection was indicated by vascular impairment from mesenteric trauma. Conditions are present in mesenteric injuries which should be expected to produce vascular thrombosis. Most important are the effects of energy transmitted to tissues, and the natural tendency to clot formation in a lacerated blood vessel. Observations have borne out the impression that thrombosis should occur in the traumatized mesentery. Thrombi were commonly found protruding from the ends of severed vessels, even those of considerable size. The thrombotic process however, was restricted to the immediate area of damage. No case of extensive mesenteric thrombosis in the usual clinical sense of the term has been encountered in which the pathology seemed primarily to be due to mesenteric trauma.*

The State of the Peritoneum in Small Intestinal Wounds.

The frequent presence of hemoperitoneum in small bowel wounds was consistent with the vascularity of the organ. Mesenteric bleeding

*One patient with a perforating wound of the upper thorax had severe abdominal symptoms. At laparotomy mesenteric thrombosis was found with gangrene of two feet of ileum, which was resected. Death occurred on the third posoperative day, and at autopsy a spicule of rib was found lodged in the wall of the ascending aorta, projecting into the lumen. A clot was attached to the tip of the bone fragment, and embolus from this point was apparently the origin of the mesenteric occlusion. The patient's death was attributed to cerebral embolus from the same source.

In another case, mesenteric thrombosis was found at autopsy in a man with a violent peritonitis.

also was on occasion massive, and cases have been seen with 2000 c.c. or more of blood in the peritoneal cavity. At the other extreme were occasional cases where bleeding had been minimal.

Contamination of the peritoneal cavity to some extent with small bowel content was the rule, although there were instances where no gross soiling was apparent. Usually the amount of contamination was consistent with the number and size of the perforations. The reaction of the peritoneum was fairly constant. Visible peritoneal reaction was unusual in cases coming to operation within six hours. Violent, exudative peritonitis when it appeared was usually seen in patients with relatively long time lag (12 hours or more). In cases surviving over 24 hours without operation there was usually early walling off with loops of bowel adherent about the perforations. Exceptions were observed however, and severe generalized peritonitis was at times seen in late cases (Case 1, Appendix), and conversely localization appeared early in some instances. Peritonitis was noted as being present at the time of operation in only 50 of 353 uncomplicated intestinal wounds. This figure is undoubtedly low, and this may be attributed to the necessary brevity of some records written under field conditions.

Evisceration of the Small Intestine.

Evisceration of the small intestine was recorded in 153 of all abdominal wounds, an incidence of approximately 5%. In 126 eviscerations there was trauma to the bowel or its mesentery which required operative repair. In the remaining cases the evisceration was incidental and demanded no treatment other than reduction. Reduction of a non-traumatized loop of intestine has sometimes been attempted in the shock ward while the patient was being prepared for surgery. As a rule however, the usual procedure has been to protect the bowel with warm, moist gauze until the time of operation. In only one case was strangulation of an eviscerated loop sufficient to demand resection. (For details of the influence of evisceration on mortality, see section on "Traumatic Evisceration", page 162).

THE MANAGEMENT OF WOUNDS OF THE SMALL INTESTINE

There have been no criteria upon which to include or exclude preoperatively the possibility of intestinal injury, and the preoperative diagnosis has been based on probability. Indriven fragments of bone and the concussive effect of missiles passing extraperitoneally have both been observed to cause intestinal perforation or rupture. It has never been safe to assume that the bowel was uninjured, and the final diagnostic criterion has been direct observation at operation whenever signs and symptoms have indicated intra-abdominal pathology.

War Injuries of the Small Intestine (The Management of Wounds of the Small Intestine).

The preoperative management of small intestinal wounds has differed in no respect from that of all abdominal wounds. The routine established for all such cases has included placement of a Levin tube in the stomach.

The surgeons of this organization have followed no rigid dicta regarding the techniques of handling of small bowel wounds, for none have been set down. The principles adhered to were similar and usually agreed upon. Most important of these principles were gentle handling, use of fine suture materials, speed, and maximum protection possible of the bowel from exposure.

Approximately one third of the surgeons felt that it was expedient to eviscerate the intestine through the operative incision and examine it outside the abdomen, rapidly replacing it as one went along its length. The complete examination of the bowel and its mesentery, as well as of other viscera, was facilitated by this procedure, and it was felt by those who advocated it that it was not appreciably shocking to the patient if speedily performed. This procedure was only used in cases with extensive damage, in which the pathology was obscured by marked spillage. Hemorrhage and frequently injury to other viscera took precedence over the operative repair of small bowel lesions. It has usually proven wise to begin the latter procedure by evaluating the entire damage to the bowel. Procedures were planned so as to provide the most rapid and safe repair.

The Repair of Trauma to the Wall of the Bowel.

Contusions and lacerations of the wall of the bowel were repaired and re-enforced by peritonealizing suture, either linear or purse string. The types of suture and material employed have been matters of individual taste.

The Repair of Perforating Trauma of the Bowel.

A wide variety of choice was available in the methods of management of perforations. Lesions of practically every conceivable size and shape have been dealt with. The principle followed has been to perform the most expedient and conservative procedure compatible with secure repair and adequate preservation of the lumen. Very small perforations were usually purse-stringed, larger ones sutured transversely. Trimming of the traumatized edges of holes was always conservative and by no means always done. It has sometimes been convenient to convert two perforations into one, particularly if they lay close together in the same vertical plane, and suture the ensuing defect. Less time was required than for two suture lines, and less kinking of the bowel resulted.

War Injuries of the Small Intestine (The Repair of Perforating Trauma of the Bowel, cont'd).

Transections were anastomosed with or without resection of short adjacent segments depending on the condition of the bowel. Among 361 transections specifically mentioned, there were 88 transections in 54 cases in which direct anastomosis was done. A large number of the total were resected along with severely mangled loops.

Resection was obviously mandatory in many cases having hopelessly macerated segments of bowel. It was also required for bowel which had been avulsed from its mesentery. The management of multiple, adjacent perforations with normal tissue between them presented more of a problem. Some surgeons performed individual sutures under these conditions, and others resected the entire segment if it was not of great length. These resections were based on the conviction that multiple suture lines close together would compromise the lumen and lead to kinking with obstruction.

Among 1117 cases having perforations into the lumen, repair by suture only was performed in 635 patients or 56.8%. Resection and anastomosis were performed in 428 or 38.3%, and anastomosis without resection in 54 cases or 4.8%. (Excluded from these figures are all cases in which resection of the terminal ileum and ileo-colostomy were the sole treatment.) The mortality for all anastomotic repairs was 37.3%, and for suture repairs it was 23.3%.

In Table II, text, and Table IV, Appendix, are presented a detailed analysis of anastomotic vs. suture repairs, with respect to frequency and mortality in the complicated and uncomplicated groups.

The ratios of mortality between anastomotic and suture repairs in the complicated and uncomplicated groups are nearly identical, and are in close proportion to the incidence of thetwo groups in the series as a whole. The frequency of the two procedures is seen also to be roughly the same for each group, with anastomosis recorded six per cent more frequently among complicated than among uncomplicated cases.

Resection and anastomosis according to frequency of types of anastomosis and mortality are shown in Table III. It is seen that the mortality for all resections in this group of cases has been 33.9%. The total number of resections done in these patients was 469, with double resections being performed in 35 instances, and triple resections in three. (Table V, Appendix), (Case 2, Appendix).

War Injuries of the Small Intestine (The Repair of Perforating Trauma of the Bowel, cont'd).

TABLE II

Frequency and Mortality of Anastomotic and Suture Repairs, 1117 Complicated and Uncomplicated Small Intestinal Injuries. 1944 - 1945

Type of Case and Total Number	ANASTOMOSIS*					SUTURE ONLY				
	Anast. Total	Anast. Frequency Percent	Lived	Died	Mort-ality Percent	Suture Only Total	Suture Frequency Percent	Lived	Died	Mortality Percent
769 Complicated Cases	347	45.1%	192	155	44.7%	422	54.9%	296	126	29.9%
348 Uncomplicated Cases	135	38.8%	110	25	18.5%	213	61.2%	191	22	10.3%
TOTALS 1117 Cases**	482	43.2%	302	180	37.3%	635	56.8%	487	148	23.3%

*Includes anastomosis of transections, without resection, in 54 cases.

**Excluded are cases having non-perforating trauma to the bowel, and those in which ileo-colostomy was the only treatment.

War Injuries of the Small Intestine (The Repair of Perforating Trauma of the Bowel, cont'd).

TABLE III

Intestinal Resections With Anastomosis, Frequency and Mortality 1944- 1945

Type of Anastomosis	Resections: No. Cases	Frequency Per Cent	Deaths	Mortality Per Cent
End-to-End	377	88.1%	120	32.0%
Side-to-Side	34	7.9%	16	47.0% *
Not Stated	17	5.0%	9	53.0%
TOTALS	428	100.0%	145	33.9%

Data were recorded as to the length of the resected segments in 394 instances. The extremes were two inches and 12 feet, and there were four cases in which segments of over eight feet were removed (Case 3, Appendix). The lengths of resections are given in tabular form in Table IV. There were 122 instances of segments greater than one foot in length being resected. In this group there were 43 deaths with a mortality of 35.2%. This figure is in close agreement with the rate of 33.9% for all resections.

TABLE IV

Intestinal Resection and Anastomosis, Lengths of Resected Segments (394 Cases) 1944-1945

Length of Segment, Inches	Number of Cases	Average Length, Inches
2" - 12"	272	6"
Over 12"	122	34"
TOTAL	394	13"

The foregoing figures support the belief that resection carries a higher mortality than does closure by suture only. In this series, the rate was higher by approximately 43% (33.9% as compared with 23.3%). The same has been true of anastomosis without resection. The difference in mortality rates cannot be explained by disproportionate distribution

*This figure is misleading. Side-to-side anastomosis was usually employed in massive resections, and the high mortality rate is a reflection of the severity of trauma in these cases.

of the procedures between complicated and uncomplicated cases, for such disproportion has not occurred to a significant degree. Furthermore, the mortality of anastomosis has been relatively greater among uncomplicated than among complicated cases when it is compared with the corresponding rates for repair by suture only (Table II, Text, and Table IV, Appendix).

It must be remembered that the principal indication for resection has been extensive trauma, and it has usually been performed for the removal of bowel which was shredded beyond hope of repair. The higher mortality is probably as much a reflection of the severity of the injuries as of dangers inherent in the procedure (Case 5, Appendix).

Many operative techniques have been employed in performances of intestinal repairs. The majority of surgeons have preferred an open, two-layer, end-to-end anastomosis. Closed methods have been used in cases having minimal soiling, and a few surgeons employed routinely a closed, two-layer, all silk technique. Side-to-side anastomosis has been reserved usually for the lower ileum, or for instances where there was a marked discrepancy in the size of the lumina to be anastomosed after extensive resections. Two surgeons report success with a single-layer anastomosis, and two have employed triple layers. Running or interrupted intestinal catgut, and interrupted fine silk or cotton have all been extensively used. All surgeons have usually employed the same types of sutures and material for the repair of perforations that they have used for anastomosis.

We have found only one instance in which enterostomy was used for the primary treatment of small bowel perforation. This was a case in which a small hole at the ileo-cecal junction was treated by performance of a tube ileo-cecostomy, and the procedure was apparently dictated by the peculiar anatomical site of the injury. It may be stated that the surgeons of this organization have found no place for enterostomy in the initial treatment of small intestinal injuries. (Trauma to the right colon and ileum was usually managed by some type of ileocolostomy, often after resection of a part of the terminal ileum. Detailed consideration of these procedures will be found in the section of this report dealing with colon injuries (Page 270).

The Management of Mesenteric Damage.

Simple through-and-through perforations of the mesentery have been sutured so as to reperitonealize the raw surfaces. In the presence of large hematomata or continuing bleeding, mesenteric dissection has obviously been indicated. The hematoma was evacuated, and the hemorrhage controlled. The mesentery was then closed by suture. As mention-

ed earlier, in only 30 instances was intestinal resection indicated by mesenteric vascular trauma. In these patients, the usual criteria of viability of the bowel have been observed and resection performed in accordance with recognized surgical principles (Case 3, Appendix).

The Management of the Contaminated Peritoneal Cavity.

The majority of surgeons have felt that drainage of the peritoneal cavity was to be condemned. Two of the group have routinely placed drains to the peritoneal space however in the presence of contamination, whether from the small bowel or other sources.

A few of the surgeons were of the opinion that lavage of the severely contaminated peritoneal cavity prior to closure of the abdomen might be of value in the removal of gross material which could not be evacuated by other means. This procedure cannot be evaluated as to its efficacy or possible dangers, for it has been used infrequently.

The employment of intraperitoneal chemotherapeutic agents is considered in detail in the section on Chemotherapy (page 197). In general, the practice of employing available drugs (sulfanilamide crystals, penicillin sodium) in this manner has been a matter of choice with the individual surgeon. One or other of the drugs or a combination of the two was employed in 59% of the cases in this series; this figure is undoubtedly low because of omission of the pertinent data in some records. No opinion as to the efficacy of the procedure in small intestinal injuries can be adduced. (Table VI, Appendix).

Postoperative Care Following Small Bowel Injury.

Ileus, distention, and vomiting were apparently almost universal phenomena among abdominal cases in the last war[5]. These dangerous conditions have been practically eliminated in our experience by the use of nasogastric decompression. Patients with abdominal wounds have had Levin tubes placed in their stomachs prior to surgery, and promptly on admission to the postoperative ward, three-bottle siphonage suction has been applied to the tubes. The custom of the surgeons has been to leave these tubes in place for from three to eight days postoperatively. There has been a strong difference of opinion as to the length of time for which decompression was necessary, but the majority seem to have favored a period of from three to six days. In all cases, the usual clinical criteria of return of intestinal function (audible peristalsis, passage of flatus, etc.) have been employed as guides.

Other routines of postoperative care of the small bowel injury

differed in no important respect from those employed in all abdominal cases. The patients were usually kept in Fowler's position until peritonitis had definitely subsided. Energetic attention was given to the maintenance of fluid and electrolyte balances, and of blood levels and nutrition. Diets were cautiously advanced after removal of the Levin tube in accordance with the patient's ability to tolerate food.

COMPLICATIONS FOLLOWING SMALL INTESTINAL WOUNDS

The incidence of postoperative complications directly related to the small bowel among these patients has been extraordinarily low, but is probably not representative of the true course of a large number of cases of this type. Complications have undoubtedly developed in a significant proportion of these men after they have passed from our care.

Intestinal Obstruction.

Among the 1168 patients having small bowel injury, there were 20 (1.7%) who developed mechanical obstructive symptoms while in the hospital of their primary surgery. Eleven of these cases had resection and anastomosis, four had anastomosis without resection, and five had repair by suture only. (There was one double resection, and two cases having resection also had simple anastomosis of transections; in ten of fifteen cases in which anastomosis was done, suture repair was also necessary for other perforations). Peritonitis had been noted at operation in two instances, and gross contamination in six; 10 of the cases had severe complicating wounds.

The time of appearance of obstructive symptoms was recorded in 17 instances, and ranged from the third to the 32nd postoperative day. The average time was between the ninth and tenth days. If two cases are omitted in which symptoms became apparent on the 32nd day, the average time is lowered to between the sixth and seventh days. This coincides fairly closely with the time at which Levin tube decompression has been discontinured, when one would ordinarily expect early obstruction first to manifest itself.

Seven patients (31%) of the 20 died. The method of dealing with the obstruction was mentioned in only one of the fatal cases*. In this instance a Miller-Abbott tube, although it did not pass the pylorus, successfully decompressed the intestine (this man died of severe

* It is safe to assume that the other patients were treated conservatively. Had surgery been performed, the fact would almost certainly have been recorded.

atypical pneumonia and hepatitis of unknown etiology).

In six of the fatal cases, autopsy data are available as to the causes of obstruction. These causes were:-

Adhesions........................	3 Cases
Kinked Anastomosis...............	1 Case
Edema at Anastomosis.............	1 Case
Peritonitis; leaking Anastomosis.	1 Case

In the remaining case autopsy was not done, but the patient developed a small intestinal fistula which was attributed to leakage of an anastomosis.

Among the 13 surviving patients, 10 were treated conservatively, with re-establishment of naso-gastric decompression being the principal therapeutic measure. In all instances the symptoms were relieved. Data are not available as to the length of time required for relief. The remaining three patients were operated upon after failure of conservative therapy. In one case obstruction was found due to adhesions, in another to adhesions and multiple abscesses, and in the third to volvulus of the ileum.

It should be noted that the Miller-Abbott tube, though readily available, has only been occasionally used. It is the consensus of opinion of the surgeons that in the majority of cases of the type with which we have been dealing, adequate decompression has been attained by a tube in the stomach, and there appeared to be little indication for a tube which lies in the intestine. This has been fortunate, for in the instances when the Miller-Abbott tube has been used, it has been found that under field conditions it has been difficult to get it past the pylorus.

Intestinal Leakage and Fistula.

There were 12 cases (1.0%) in which small bowel leakage occurred postoperatively, and in nine of these fistulae developed. (Not included is the case of a German Prisoner of War who was admitted to the hospital three days after wounding with an established small bowel fistula and intraperitoneal abscess. Case 4, (Appendix)). In the eight cases where the time of development of the complication is given, it occurred between the sixth and 26th postoperative days. The average time at which leakage was first observed was on the 13th postoperative day. Six of the 12 patients had severe complicating wounds of other hollow viscera.

In three patients the leak was proved at autopsy to have occurred

War Injuries of the Small Intestine (Intestinal Leakage and Fistula, cont'd).

at suture lines, and in two cases it was assumed to have had a similar origin. In one instance, two perforations of the terminal ileum were attributed to erosion by wire through-and-through sutures which had been used to repair a dehiscence on the ninth postoperative day. The patient died of peritonitis on the 22nd day, and the perforations were found at autopsy. Data as to the origin of leakage in the remaining cases are not given.

Secondary operation for closure of fistula was not done in the forward hospitals. It was believed that patients with this complication were best evacuated immediately to a general hospital where facilities for prolonged care were available, and this policy was followed.

Small bowel leakage proved as always a serious matter, and five of the 12 patients died. Two of the nine cases having external fistulae died, and leakage without the establishment of fistula was fatal in all three cases in which it occurred. In four of the five fatalities, death was attributed to peritonitis; in the fifth, the cause was not stated.

ASSOCIATED INJURIES

Among the 1168 cases with small intestinal injury, 252 had what may be classed as major associated wounds, and in 202 minor associated wounds were present. An additional 143 patients had penetrating or perforating wounds of the thorax; 94 of these were thoraco-abdominal wounds (8% of all small bowel injuries), and 49 were associated chest wounds. In summary, it is seen that 597 or almost exactly half of all cases associated wounds were present. In 395 cases (major peripheral plus thoracic wounds) or one third of all, the associated wounds were of a major nature.

UNCOMPLICATED SMALL BOWEL WOUNDS

There were 353 uncomplicated wounds of the small intestine, an incidence of 11.2% of the entire series of 3154 abdominal injuries. These cases represented 30% of all small bowel injuries. Two non-battle injuries of the small intestine are included. The remaining 351 patients were all wounded by high explosive fragments or bullets. There were 49 deaths, the mortality rate being 13.9%.

The ileum was injured more frequently than the jejunum, the ratio being roughly three to two. Both portions of the bowel were injured simultaneously only one fourth as frequently as was the ileum alone. Mortality rates for wounds of the jejunum and ileum separately were approximately the same (10.2% and 12.8% respectively). Among injuries

War Injuries of the Small Intestine (Uncomplicated Small Bowel Wounds, cont'd).

involving both ileum and jejunum, the mortality rose sharply to 29%. This is attributable to the fact that many such injuries represent very extensive trauma to a large segment of the mid-bowel. It is largely among this group that the most massive resections have been performed. The incidence and mortality by anatomical portions of the bowel are summarized in Table VII (Appendix).

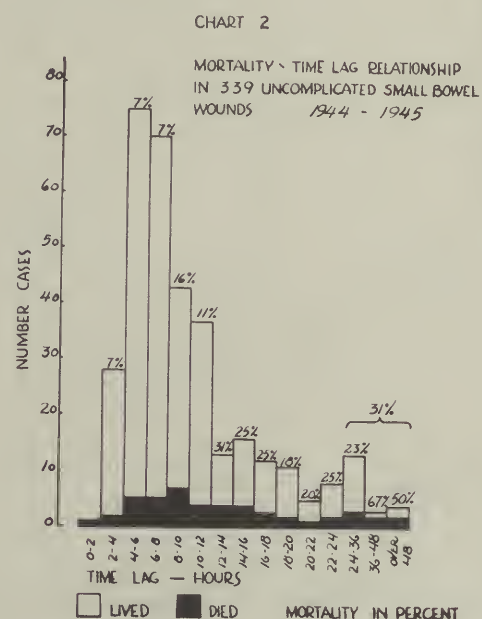


Figure 36 - Mortality-Time Lag Relationship

It has been found that the average time lag among patients dying with uncomplicated small bowel injuries was just twice that among those who survived. (Table V, Figures 36 and 37). The impression

War Injuries of the Small Intestine (Uncomplicated Small Bowel Wounds, cont'd).

is inescapable that if patients with this type of injury can be operated on within eight hours of wounding, their chances of recovery are enhanced.

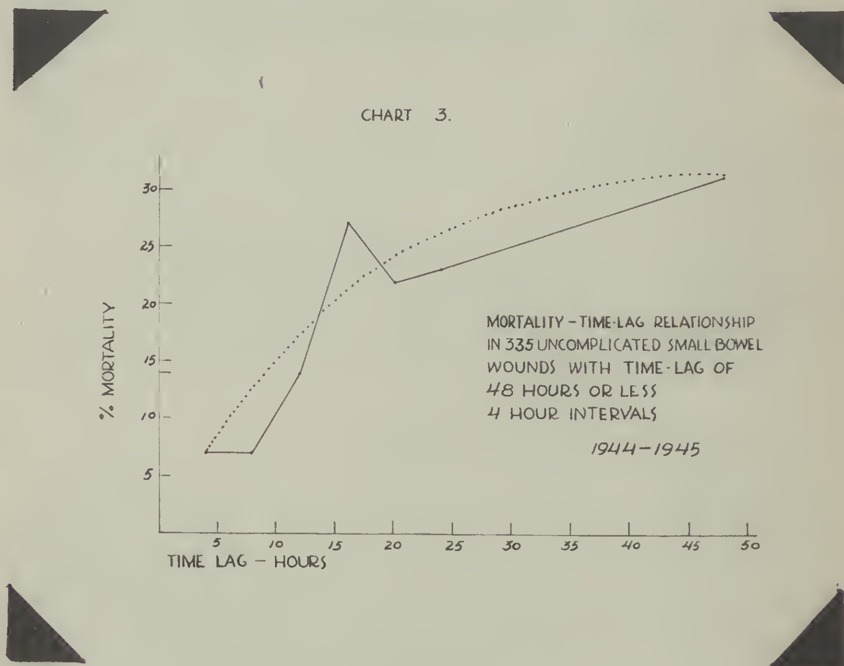


Figure 37 - Mortality-Time Lag Relationship

TABLE V

Average Time Interval, Wounding to Operation, Small Intestinal Wounds
1944 - 1945

		Time Lag, Wounding to Operation Hours
All Small Bowel Cases	1057 Cases*	10.6 hours
Uncomplicated	339 Cases	10.9 hours
Uncomplicated, Survived	293 Cases	9.5 hours
Uncomplicated, Died	46 Cases	10.1 hours**

*Number of cases for which data are available.

**If two cases of unusual delay, 72 and 90 hours respectively are omitted, this figure becomes 16.3 hours.

War Injuries of the Small Intestine (Uncomplicated Small Bowel Wounds, cont'd).

It appears that a disproportionate number of severe associated injuries has contributed to the mortality. Such wounds were more than twice as frequent among the fatal cases as among those which survived. A major associated wound is considered as included in the following:- complete compound fractures of long bones, traumatic amputations other than of digits, penetrating wounds of the thorax other than thoraco-abdominal, severe cranial injury, severe maxillo-facial injury, and soft tissue wounds which were very extensive or productive of severe hemorrhage. Such wounds were recorded in 72 or 24% of the 304 patients who survived in the uncomplicated group. In contrast, major associated wounds were observed in 27 or 55% of the 49 fatal uncomplicated cases.

The recorded incidence of peritonitis observed at the time of operation is probably low, due to omission of information in some records. Nevertheless it is of interest that among the uncomplicated cases which died, peritonitis was specifically mentioned in the surgeon's operative notes as being present in 41% of cases, as contrasted with only 10% among the patients who lived.

Deaths occurring among battle casualties within the first 48 hours postoperatively, unless due to a surgical or anesthetic catastrophe, are practically always indicative of wounds of extreme or even mortal severity. Such cases commonly are not responsive to surgical or resuscitative measures however heroic, and the usually cited causes of death are "shock", "shock and hemorrhage", or "shock and peritonitis" (Case 5, Appendix). With these observations in mind, it has been found that of the 49 fatal cases under consideration 15 or 31% survived operation by less than 24 hours, and another ten cases or 20% died between 24 and 48 hours. These figures imply that a significant proportion of deaths occurred among patients with wounds of more than average severity as compared with the uncomplicated group as a whole. The postoperative survival times for the fatal cases are represented graphically in Figure 38 . The average survival time for all these cases was 3.6 days.

War Injuries of the Small Intestine (Uncomplicated Small Bowel Wounds, cont'd).

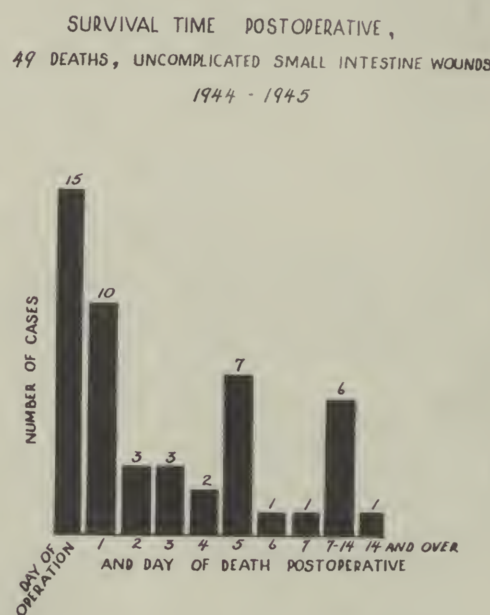


Figure 38 - Postoperative Survival Time Among Fatal Cases.

There were three cases among the 49 fatalities in which death may justifiably be attributed primarily to associated injuries. One was a death on the operating table from cardiac tamponade, one a death five hours postoperatively from pulmonary blast injury, and one death was attributed to hemolytic streptococcal bacteremia and pyemia from infection in a massive wound of the thigh. Necropsy was done in all three cases.

In addition to the cases mentioned above, there were 15 in which death was apparently due to the combined effects of intestinal and

associated wounds, both of which were severe. Case 6 (Appendix) is cited as an example of this group. If we exclude from discussion the 18 cases in which death was attributable in whole or in large part to associated wounds, a more accurate impression may be gained as to the causes of death among patients in whom the small bowel injury was the primarily fatal factor.

There were 31 such cases in this group, and pertinent data regarding these patients are summarized in Table VIII (Appendix). "Shock" and/or "peritonitis" were listed as causes of death in 15 patients who survived operation for periods of time varying from five minutes to two days. These cases fall into a well-defined group of casualties seen in forward hospitals, who come to the hospital in severe shock which seems in part to be secondary to massive peritoneal contamination. The time lag is usually long and associated hemorrhage is frequent. Death occurs in the early postoperative period. Forty-eight per cent of the 31 deaths under consideration fall into this group.

"Peritonitis" is listed as the primary cause of death in eight cases who survived operation for periods varying between three and 22 days. In these patients an established, uncontrollable infection within the peritoneal cavity, without the element of traumatic shock, was the primary cause of death.

One death was attributed to intestinal obstruction. The remaining seven patients (excepting one in which cause of death was not given) died of complications not peculiarly related to wounds of the small intestine (pulmonary embolism, anuria, etc.).

Summarizing the data on Table VIII (Appendix) it is seen that approximately one half of the cases died in the immediate postoperative period of overwhelming wounds and contamination, one fourth died of peritonitis, and the remaining fourth died of unpredictable complications, including one patient with intestinal obstruction. The outstanding factors contributing to mortality among cases dying with small bowel injuries as the primary cause of death appear to be shock in association with severe peritoneal contamination, prolonged time lag, and peritonitis. Interaction among these factors has been observed clinically and they have appeared to be mutually complementary. It is not possible completely to divorce one from the others for statistical analysis.

SUMMARY AND CONCLUSIONS

A review has been made of small intestinal injuries occurring in a series of 3154 abdominal and thoraco-abdominal wounds. The cases studied were all treated in forward surgical installations by surgical teams of the 2nd Auxiliary Surgical Group. Six cases of non-penetrating trauma to the abdomen were included; all other wounds but one were caused by missiles. Small bowel injury was present in 37% of all cases. Uncomplicated small bowel wounds numbered 353 and comprised 11.2% of the entire series.

The gross mortality rate for all small intestinal wounds was 30%. The mortality in the uncomplicated group was 13.9%.

A section is included on the nature of the trauma to the intestine and its mesentery as it has been observed, and another section is devoted to the techniques of management employed by the surgeons of this Auxiliary Surgical Group. The majority of perforations were repaired by suture. The mortality among all cases having repair by suture only was 23.3%. Resection and anastomosis were performed in 428 cases. The mortality in this group was 33.9%, with 145 deaths. Double resections were performed 35 times, and triple resections three times.

Enterostomy was not employed as a method of primary treatment of small intestinal wounds.

Postoperative distention, ileus, and vomiting have not been frequent. The elimination of these conditions is attributed to the routine use of naso-gastric suction for decompression of the gastro-intestinal tract. The Levin tube has been found most satisfactory for this purpose.

Twenty cases of intestinal obstruction and 12 cases of intestinal leakage following small bowel surgery have been observed. The combined incidence of these complications was 2.7% of all cases. The average time of manifestation of obstruction was between the sixth and seventh postoperative days, and of leakage, on the 13th day.

Major associated wounds were presentin one third of all cases. Eight per cent of all small intestinal injuries occurred in thoraco-abdominal wounds.

Among 353 uncomplicated wounds, the ileum was injured more frequently than the jejunum in a ratio of approximately three to two.

War Injuries of the Small Intestine (Summary and Conclusions, cont'd).

Ileal wounds were only slightly more lethal than were those of the jejunum.

The average time lag from wounding to operation in uncomplicated cases was 10.9 hours. Among those cases which survived it was 9.5 hours, and among fatal cases it was 19.1 hours.

Major associated trauma was observed over twice as frequently among fatal uncomplicated cases as among those which lived, and contributed materially as a cause of death in approximately one third of all fatal cases in the uncomplicated group. Among the remaining two thirds, 48% survived operation by less than 72 hours. Prolonged time lag was a prominent factor, and peritonitis was the most frequent cause of death in patients dying primarily of small bowel injuries who survived operation by more than two days.

REFERENCES

1. Report on the Surgery of Abdominal Wounds; unpublished data submitted to the Commanding Officer, 2nd Auxiliary Surgical Group (13 August 1943).

2. Report on the Surgery of Abdominal Wounds; unpublished data submitted to the Commanding Officer, 2nd Auxiliary Surgical Group (14 April 1944).

3. The Medical Department of the United States Army in the World War. Vol. XI. Surgery. Part 1. Page 458. (Washington; Government Printing Office., 1927).

4. ibid. Page 460.

5. ibid. Page 455.

War Injuries of the Small Intestine.

APPENDIX

List Of Tables | Page

Cases Referred to In the Text

War Injuries of the Small Intestine (Appendix, cont'd).

TABLE I

Incidence of Wounds to the Small Intestine in all Abdominal Wounds (Including Thoraco-Abdominal and Non-penetrating Injuries) 1942 - 1945

	1942-43	1944	1945	Total	Percent of All Abdominal
Abdominal Wounds	378	2383	771	3532	100.0%
Small Bowel Involved	129	849	319	1297	33.9%
Small Bowel Only	59	259	94	412	11.7%

TABLE II

Gross Mortality Rates, All Cases Having Small Intestinal Injury 1942 - 1945

Year	Cases, Small Bowel Injury	Deaths	Mortality Percent
1942-1943	129	47	36.4%
1944	849	252	29.7%
1945	319	93	29.2%
TOTAL	1297	392	30.2%

War Injuries of the Small Intestine (Appendix, cont'd).

TABLE III

Incidence of Types of Injury to the Small Intestine. (Combinations of Different Types are Included)
1944 - 1945

Type of Trauma	Number of Cases	Number of Injuries	Average Frequency per Case
Injury to Wall Only	27	31	1
Severe Mesenteric Injury*	30	30	1
Transection	213	361	2
Perforation**	1083	4589	4

*Requiring resection.
**An arbitrary figure of 5 has been used where "multiple" perforations are recorded. The true figure is probably higher.

TABLE IV

Distribution of Anastomotic and Suture Repairs, 1117 Complicated and Uncomplicated Small Intestinal Injuries, 1944-45.
(Compare with Table II in Text)

	Total	Complicated Cases		Uncomplicated Cases	
	Cases	Number	Percent	Number	Percent
Total Series	1117	769	68.8%	348	31.2%
Anastomosis	482	347	72.0%	135	28.0%
Suture Only	635	422	66.5%	213	33.5%

War Injuries of the Small Intestine (Appendix, cont'd).

TABLE V

Multiple Resections, Mortality (All multiple resections had end-to-end Anastomosis) 1944-45

	Number Resections Per Case	
	2	3
Survived	22	1
Died	13	2
Total	35	3
Mortality	37%	67%

TABLE VI

Small Intestinal Wounds, 1944-1945. Frequency of Use of Intraperitoneal Chemotherapeutic Agents. (Sulfanilamide Crystals, Penicillin, or Both).

	Total Series 1168 Cases		Uncomplicated 304 Survived		Uncomplicated 49 Died	
	Number	Percent	Number	Percent	Number	Percent
Drugs Used	684	59%	212	70%	31	63%

War Injuries of the Small Intestine (Appendix, cont'd).

TABLE VII

Uncomplicated Small Intestinal Injuries, 1944-45. Incidence and Mortality of Injuries to the Jejunum and Ileum

	JEJUNUM		ILEUM		BOTH		TOTAL			
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Mortality	
1944	96	10	135	15	28	8	259	33	12.7%	1944
1945	32	3	45	8	17	5	94	16	17.0%	1945
TOTAL	128	13	180	23	45	13	353	49	13.9%	TOTAL

MORTALITY	JEJUNUM	ILEUM	BOTH	TOTAL
	10.2%	12.8%	29.0%	13.9%

War Injuries of the Small Intestine (Appendix, cont'd).

TABLE VIII

Causes of Death in 31 Cases Having Small Intestinal Injury the Primarily Fatal Wound

1944 - 1945

	Time Lag Hours	Auto-psy	Survival Post-op.	Site of Injury	Cause of Death
1.	4	Yes	8 days	Ileum	Generalized and localized purulent peritonitis; leaking anastomosis
2.	8	Yes	36 hours	Jejunum & Ileum	Peritonitis; shock
3.	90	No	4 days	Jejunum	Generalized peritonitis (clinical)
4.	19	Yes	2 days	Ileum	Generalized peritonitis, severe. Pulmonary edema, severe.
5.	17	Yes	2 hours	Jejunum	Shock; peritonitis. (Clinical)
6.	12	No	24 hours	Jejunum & Ileum	Shock (clinical)
7.	$14\frac{1}{2}$	Yes	5 days	Ileum	Peritonitis, suppurative, generalized, severe; mesenteric thrombosis lower 1/3 ileum.
8.	$23\frac{1}{2}$	Yes	8 days	Jejunum	Acute fibrinopurulent peritonitis, severe. (Anuria, uremia..clinical) (Case 1, Appendix)
9.	20	No	2 days	Jejunum & Ileum	Shock (clinical)
10.	36	No	36 hours	Jejunum	Shock; severe mesenteric hemorrhage (clinical)
11.	27	Yes	9 hours	Ileum	Generalized fibrinopurulent peritonitis present at operation.
12.	14	Yes.	22 days	Jejunum & Ileum	Two perforations ileum due to wire sutures. Generalized and localized peritonitis.
13.	6	No	3 days	Ileum	Peritonitis (clinical)
14.	36	No	5 hours	Ileum	Shock; peritonitis (clinical)
15.	22	No	5 min.	Jejunum & Ileum	Shock; peritonitis (clinical) (Case 5, Appendix)

War Injuries of the Small Intestine (Appendix, Table VIII cont'd)

	Time Lag Hours	Auto-psy	Survival Post-op	Site of Injury	Cause of Death
16.	15	No	11 days	Ileum	Peritonitis (clinical)
17.	7	Yes	10 days	Ileum	Massive Pulmonary embolism
18.	?	No	5 hours	Jejunum & Ileum	Shock (clinical)
19.	16	Yes	5 days	Jejunum & Ileum	Oliguria, anuria, uremia
20.	4	Yes	1 day	Ileum	Cardio-respiratory death unexplained clinically or at autopsy.
21.	13	No	24 hours	Jejunum	Shock; peritonitis (clinical)
22.	48	No	$8\frac{1}{2}$ hours	Ileum	Shock; peritonitis (clinical)
23.	10	Yes	5 days	Ileum	Intestinal obstruction; kinked anastomosis
24.	$11\frac{1}{2}$	Yes	24 hours	Jejunum & Ileum	Generalized peritonitis
25.	37	No	14 hours	Jejunum & Ileum	Shock; peritonitis (clinical)
26.	$6\frac{1}{2}$	Yes	3 days	Jejunum	Diffuse purulent tracheobronchitis
27.	7	Yes	12 days	Jejunum & Ileum	Generalized peritonitis; bronchopneumonia
28.	?	No	5 days	Jejunum & Ileum	Not stated
29.	10	Yes	24 hours	Jejunum & Ileum	Generalized peritonitis (Shock, clinical)
30.	$5\frac{1}{2}$	Yes	10 min	Ileum	Aspiration of Vomitus
31.	$6\frac{1}{2}$	Yes	13 days	Jejunum	Hepatitis; atypical pneumonia; intestinal obstruction.

War Injuries of the Small Intestine (Appendix, cont'd).

Cases Referred to in Text.

1. A 29 year old American infantryman, wounded by a machine gun bullet which entered the left lower abdomen, fractured the ilium, and fractured the greater trochanter of the femur at the wound of exit. The patient arrived in the Field Hospital 20 hours after injury, in severe shock. He was given one unit of plasma and five pints of blood preoperatively. He was mentally disoriented on admission (anoxia).

At operation 24 hours after wounding, the surgeon noted, "This patient had the most extensive spillage of intestinal contents I have ever seen. Peritonitis is generalized and fulminating". There was only one small perforation found, in the jejunum. This was repaired by suture.

Postoperatively the patient remained toxic, developed oliguria which progressed to anuria, and he died on the eighth postoperative day. At necropsy, an acute, fibrinopurulent, generalized peritonitis was found, with subphrenic abscess on the right side as well. (Case No. 8 in Table VIII Appendix - same case).

2. A 42 year old American artilleryman, wounded by a shell fragment which penetrated the abdomen through the left lower quadrant. He arrived in the Field Hospital in good condition, and was given 500 c.c of blood. Roentgen examination disclosed a metallic foreign body in the right lower quadrant.

Operation was performed eight hours after injury. "Multiple perforations of very large size" were found in the small bowel, necessitating resection of three separate loops of intestine. At each resection, and end-to-end anastomosis was performed. One resection was in the jejunum, one in the upper ileum, and one in the lower ileum. The large shell fragment was removed from the wall of the ileum.

The postoperative course was uneventful. He was evacuated in good condition, taking liquid diet, on the eighth postoperative day.

War Injuries of the Small Intestine (Appendix, Cases Referred to in Text, cont'd).

3. An American medical corpsman sustained a severe penetrating gunshot wound of the left abdomen. He arrived at the Field Hospital about two hours after injury. He was in severe shock, and the blood pressure and pulse were not obtainable. After 2500 c.c. of blood had been rapidly administered, the pulse was perceptible, but could not be counted, and the blood pressure was 52/40 mm. Hg. The patient presented a large defect in the abdominal wall, with extensive evisceration of small intestine.

Operation was performed three hours after injury. The root of the mesentery was found to be avulsed, with severe and persistent bleeding. There were multiple transections and lacerations of the ileum and jejunum. The missile had perforated the left mesocolon, and lay in the lumbar musculature. Ten feet of small intestine were resected because of vascular impairment; side-to-side anastomosis was done. Several perforations of the jejunum were sutured. Following control of the hemorrhage the patient's condition gradually improved, and at the end of the operation the blood pressure was 104/60 mm. Hg. One transfusion of 500 c.c. was given during the operation.

The postoperative course was good. The Levin tube was removed on the sixth day, and the patient had spontaneous bowel movement. He was evacuated on the 13th postoperative day in good condition. (He reported by letter one month later that he was doing well, and ready for evacuation to the Zone of the Interior).

4. A German Prisoner of War, wounded by a shell fragment which penetrated the right lower quadrant of the abdomen. He was admitted to the Field Hospital three days after injury, dehydrated but otherwise in good condition. There was tenderness in the right lower abdomen, and a thin, watery discharge exuded from the wound.

At operation, the wound was lengthened so as to make a modified gridiron incision. A large abscess cavity was entered, which lay anterior to the cecum. Within the abscess cavity was a perforated loop of ileum. A tube ileostomy was done through the perforation.

Postoperatively the patient did fairly well, but in the ileostomy discharges were noted undigested food particles, and the note was made that the perforation had probably been higher than originally thought. It was suggested that an effort at closure of the intestinal perforation might have been preferable to ileostomy. The patient was evacuated on the tenth postoperative day.

War Injuries of the Small Intestine (Appendix, Cases Referred to in Text, cont'd).

5. An 18 year old German Prisoner of War was admitted to the Field Hospital approximately 20 hours after sustaining a penetrating shell fragment wound of the abdomen. He was in severe shock, which did not respond satisfactorily to vigorous resuscitation therapy.

Operation was performed 24 hours after injury. Marked contamination with small bowel content and a plastic peritonitis were noted. The bowel was of poor color. Three segmental resections of small bowel were done, removing a total of about three feet of badly damaged intestine. End-to-end anastomoses were done, the highest of them about four inches below the ligament of Treitz. Several perforations were repaired by suture.

In spite of continued infusions of blood during operation, the patient's condition became progressively worse on the table, and he died about five minutes after the completion of surgery. Prolonged shock was stated as the cause of death. (Case 15, Table VIII, Appendix-same case).

6. An American infantryman sustained a severe shell fragment wound of the right buttock. He was brought to the Field Hospital in severe shock about 20 hours after wounding. Three thousand c.c of blood were given for resuscitation, and operation was commenced about 24 hours after the time of injury. Two small perforations of the ileum were found, and there was an early fibrinous peritonitis.

There was a very severe wound of the buttock, with an associated phagedenic infection involving the entire gluteal muscle group, and the lumbar and posterior thigh muscles. The patient became oliguric and uremic, and died on the fifth day after a rapidly downhill course. The extensive infection proved impossible to control. At autopsy the peritoneal cavity was found clean. The infection and necrosis in the buttock and thigh were severe. The buttock wound and associated sepsis were stated as the chief causes of death.

WOUNDS OF THE COLON AND RECTUM

The total number of patients with intra-abdominal wounds operated on by surgeons of this Group from 1943 through May 1945 was 3532. Of this series 1358 were patients with wounds of the colon and rectum or both, or 38.4% of all patients with wounds of the abdomen.

TABLE I

Incidence of Colon and Rectum Cases

Total Abdominal Cases	3532
Total Colon and Rectum Cases	1358
Percent Colon and Rectum Cases	38.4%

Of these 1358 patients with colon or rectum wounded and undergoing laparotomy, 867 lived and 491 died, a mortality rate of 36.17%.

TABLE II

Mortality Rate

Total Colon and Rectum Cases	1358
Deaths	491
Percent Mortality	36.17%

During the year 1943 (from April through December 31) 136 laparotomies were done on that number of patients for colon and rectum wounds. Seventy-eight of these patients lived and 58 died. The mortality rate was 42.6%. This series of 136 cases during 1943 has been previously reported by this Group and will not be included in this report of colon and rectum cases for the years 1944 and 1945. (See Table III).

TABLE III

Colon and Rectum Cases

Year	Number Patients	Deaths	Percent
1943	136	58	42.6%
1944	917	334	36.42%
1945	305	99	32.45%
TOTAL	1358	491	36.17%

From 1 January 1944 through 8 May 1945 there were 1222 patients with wounds of the colon or rectum or both, who underwent laparotomy.

Wounds of the Colon and Rectum.

This series has not been previously reported and the following report of statistics will refer only to this group unless otherwise stated.

For the survey of the case records of patients it was decided that the entire large bowel, including the rectum, be divided into five portions and listed anatomically as follows: (1) ascending colon; (2) transverse colon; (3) descending colon; (4) sigmoid colon and (5) rectum, extraperitoneal. There are further classifications of combinations of these various portions such as, ascending and transverse colon, etc.

All cases included in this report had perforations or severe damage or interruption of the blood supply to the colon or rectum so that surgical intervention was necessary. No cases were included in which the perforation was not actually into the bowel lumen, nor were there included sub-serosal hematomas and minor bruises of the bowel. In Table IV, below, are listed 1106 cases with colon wounds. Of this number of cases, 251 were uncomplicated by involvement of other abdominal viscera and revealed a mortality rate of 23%. Eight hundred fifty-five patients with colon wounds had complicating injuries of other abdominal viscera with a mortality rate of 40.8%.

The 155 cases listed as rectum are cases that had perforations of the rectum. Sixty-four of these patients had only involvement of the extraperitoneal rectum and had a mortality rate of 14%. However, in 91 patients, rectal perforations were complicated by wounds of abdominal viscera including colon. This series had a mortality rate of 41.8%. Of this last group mentioned 39 had wounds of the colon and of the extraperitoneal rectum. See Table IV.

TABLE IV

Incidence and Mortality Rate*

	GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
	No. Cases	Incidence in 3154 cases	Mort. Rate (Gross)	No. Cases	Incidence in 1222 cases	Mort.	No. Cases	Incidence in 1222 Cases	Mort.
Colon	1106	35.0%	36.7%	251	7.9%	23%	855	27.1%	40.8%
Rectum	155	4.9%	30.3%	64	2.3%	14%	91	2.8%	41.7%

*Thirty-nine cases are duplicated because of wounds of both the colon and rectum.

Wounds of the Colon and Rectum.

AGE

(1106 Colon and Rectum Cases)

All but a few of the patients in this series were soldiers - American, Allied and Prisoners of War. Most, therefore, fall into the same age group. One fourth of the patients were twenty years of age or under and almost three fourths were between twenty and forty. The mortality rate was the same for both groups. A total of 22 patients were over fofty years old and their mortality rate was 46%.

TABLE V

Age - (1006 Cases)

Years	Patients	Percentage Total	Died	Percentage Mortality
0 - 20	250	25%	81	32.4%
21 - 39	734	73%	248	32.3%
40 and over	22	2.2%	10	45.5%

In the "under 20" age group were included civilian children who, although not considered separately, had a mortality rate above the average.

TIME LAG- WOUNDING TO OPERATION

(1222 Colon and Rectum Cases)

The average time elapsed between time of wounding and the onset of operation in all cases was 10.9 hours. This compares with 11.3 hours reported by Jarvis of this Group for all abdominal cases in 1943 and 10.1 hours in all abdominal cases in this series. The time interval was essentially the same for fatal and non-fatal cases.

Of special interest is the fact that 27% of these cases had operations begun within six hours of injury and 75% within 12 hours. (See Table I, Appendix).

The average resuscitation time was approximately 3hours and the time of wounding to admission about eight hours.

Wounds of the Colon and Rectum.

TABLE VI

Time Lag - Wounding to Operation (1222 Colon and Rectum Cases)

		0-6 hrs	6-12 hrs	12-18 hrs	18-24 hrs	24-48 hrs	48 hrs plus
Colon and Rectum	Patients	336	575	168	66	65	12
	Deaths	105	215	65	20	25	3
	% Mortality	31.3%	37.4%	38.7%	30.3%	38.5%	25.0%
Rectum Only	Patients	15	57	23	11	10	
	Deaths	5	12	7	1	2	
	% Mortality	33.3%	21.0%	30.4%	9.0%	20.0%	
Colon	Patients	321	518	145	55	55	12
	Deaths	100	203	58	19	23	3
	% Mortality	31.2%	39.2%	40.0%	34.5%	41.8%	25.0%

The advantage to the patient of a short time interval is particularly marked when there is intraperitoneal colon injury. The mortality rate jumps from 31 to 40% between the first and third six hour period. Apparently there is not the same danger of delay in rectal injuries in those with intraperitoneal lesions other than colon.

The death rate when surgery was begun within 12 hours of wounding was 36.1%. This is in spite of the obvious fact that included in this group are those patients very critically and often mortally wounded, who get to a hospital only because of very early evacuation (See Fig.

A short time interval seems to lower the mortality in colon injuries and, in addition, it gives a chance of survival to many patients who with a longer interval would die without benefit of surgery.*

*A detailed discussion of the factor of time lag and its relation to mortality may be found in the introduction to this section on wounds of the abdomen, page 132.

Wounds of the Colon and Rectum.

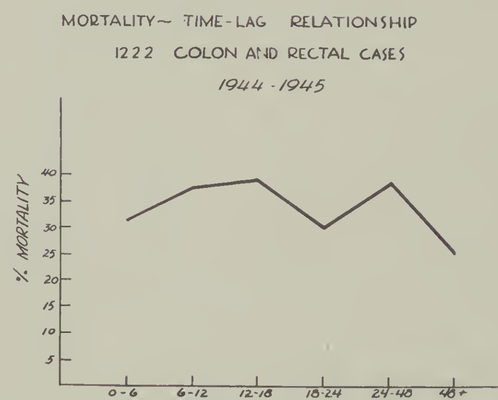


Figure 39 - Mortality - Time Lag Relationship (1222 Colon and Rectal Cases, 1944 - 1945)

COMPLICATING ABDOMINAL INJURIES

(1222 Colon and Rectum Cases)

Colon and rectum injuries were complicated by injury to one or more additional abdominal organs in three out of every four cases (73%). Complicating injuries increased the mortality rate very appreciably and the increase was in direct proportion to the number of other organs injured. There was little difference in the increased rate between complicating hollow and solid organ injuries but when both hollow and solid organs were additionally injured, the rate increased markedly. Injuries of the extraperitoneal rectum alone offered the best chance of survival. In these, the rate was 14% compared to 23% in uncomplicated colon injuries.

Major intra-abdominal vascular injuries were frequent enough to be important. Although not considered in the following tables, there were

Wounds of the Colon and Rectum. (Complicating Abdominal Injuries contd)

25 cases with 23 deaths in which a major vessel lesion was a complicating factor. Eight of these with six deaths were patients in which colon alone was involved in addition to the vascular injury.

TABLE VII

Complicating Abdominal Injury (1222 Colon & Rectum Cases)

	No Other Injury			Hollow Viscera			Solid Viscera			Hollow & Solid Viscera		
	No. Pts.	Dead	Pct.	No. Pts.	Dead	Pct.	No. Pts.	Dead	Pct.	No. Pts	Dead	Pct.
Right Colon	107	20	19%	122	41	33%	35	15	43%	18	11	61%
Transverse colon	60	14	23%	140	51	36%	100	30	30%	117	68	56%
Left Colon	65	17	26%	176	63	36%	19	6	32%	17	8	47%
Multiple colon	19	6	32%	42	21	50%	5	4	80%	25	13	52%
Rectum	64	9	14%	47	16	34%	2	0	0	3	2	66%
Colon and rectum	13	6	46%	25	13	52%				1	1	100%
TOTAL	328	72	22%	552	205	37%	161	55	34%	181	101	56%

It should be borne in mind that in cases having complicated injuries to both hollow and solid viscera there are always three or more organs involved. The significance of the multiplicity factor is discussed below.

MULTIPLICITY OF ABDOMINAL ORGAN INVOLVEMENT

(1155 Colon and Rectum Cases)

In the study of abdominal wounds it became apparent that there was an increase in the mortality rate which was proportionate to the number of organs injured within the abdomen. In order to determine whether this observation held good when the large bowel was injured, 1155 cases of colon and rectum wounds were studied. Here too, there was a definite and almost arithmetical increase in the mortality rate from 19.5% in uncomplicated colon and rectum*cases to 100% when the colon

*The mortality rate for colon alone was 23% and for rectum alone was 14%.

Wounds of the Colon and Rectum. (Multiplicity of Abdominal Organ Involvement, 1155 Colon and Rectum Cases, contd)

and five other organs were injured. Thus, the prognosis in these cases depends to a great extent upon the number of additional organs injured rather than upon which organ or organs. However, uncomplicated colon injuries carry with them a higher death rate than any other single abdominal organ in this series with the exception of stomach and pancreas (only one case). It seems that the number of organs involved is of greater importance upon the prognosis than the time lag between injury and operation (See Combined Effect Upon Mortality Rate of Time Lag and Muliplicity of Organs Involved, Page 132 and Table III, Appendix).

TABLE VIII

Effects of Complicating Organ Involvement (1155 Colon and Rectum Cases)

	Patients	Deaths	Percent Mortality
Colon or Rectum* alone	292	57	19.5%
Colon or Rectum plus 1 organ	533	172	32.3%
Colon or Rectum plus 2 organs	233	112	48.0%
Colon or Rectum plus 3 organs	70	37	52.9%
Colon or Rectum plus 4 organs	22	18	81.8%
Colon or Rectum plus 5 organs	5	5	100.0%

*The mortality rate for colon alone was 23% and for rectum alone was 14%

Wounds of the Colon and Rectum.

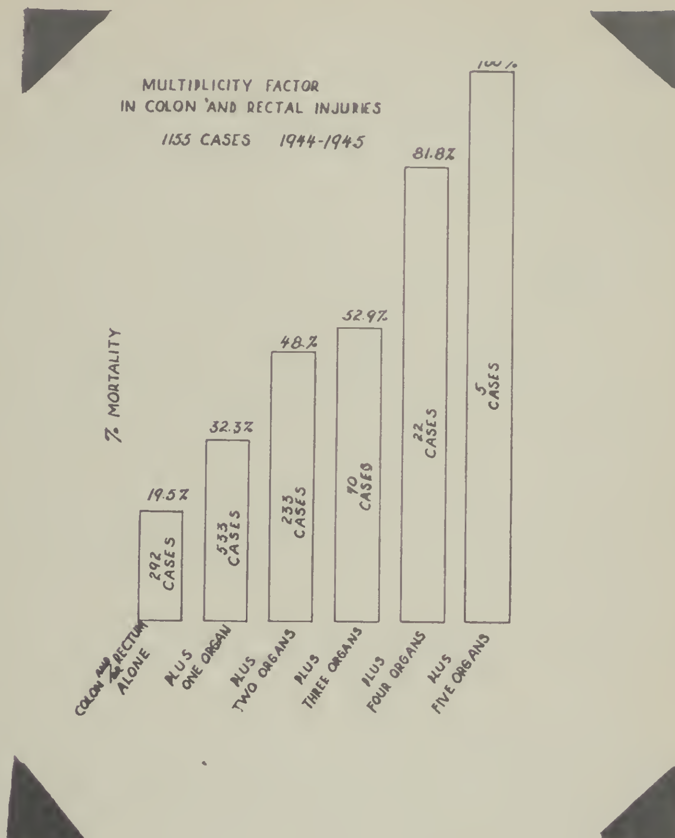


Figure 40 - Multiplicity Factor in Colon and Rectal Injuries.
1155 Cases - 1944-1945

COMBINED EFFECTS UPON MORTALITY RATE OF TIME LAG AND MULTIPLICITY OF ORGANS INVOLVED

(1155 Colon and Rectum Cases)

In this study the effects of time lag and numbers of organs involved are compared graphically and by chart. With each additional organ injured there is a consistent increase in mortality regardless of the time lag. Two minor exceptions are to be disregarded because of insignificant figures. There is no such pattern of the death rate in the successive periods of time after injury, when examined with regard to

number of additional organs injured. This does not mean that time lag is unimportant. Because of the greater danger of infection of the peritoneum, it is probably more important in colon injuries than elsewhere (See TIME INTERVAL - WOUNDING TO OPERATION). It does seem to mean though, that the dangers of operative delay, the chief of which is peritonitis, are less than the hazards of multiple organ injury, the chief of which is probably shock (See Table III, Appendix).

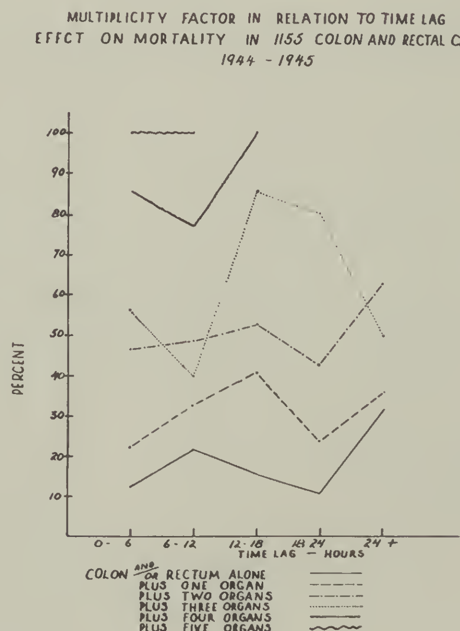


Figure 41 - Multiplicity Factor in Relation to Time Lag Effect on Mortality in 1155 Colon and Rectal Cases, 1944-45.

RELATED THORACO-ABDOMINAL INJURIES

(1358 Colon and Rectum Cases)

Colon injuries were complicated by injuries of the chest through the diaphragm 191 times or in 14% of cases. The mortality was 50%. (See Table IV, Appendix).

SHOCK ON ADMISSION

(1140 Colon and Rectum Cases)

It was possible to classify 1140 patients with colon and/or rectum injuries according to their degree of shock on admission. Three groups were used: 1) No shock, or slight; 2) Moderate; and 3) Severe. Various factors were used in classifying these patients. Consideration was given to admission blood pressures, statements about the degree of shock, appearance, amounts of blood and plasma used in resuscitation, and response to shock treatment. There was almost an even distribution of the patients into the three groups.

Mortality was 10% in patients with slight or no shock, 29% in those with moderate shock, and 69% in patients with severe shock. (See Table IV, Appendix).

A study was made of shock in relation to time interval between times of wounding and admission. There was little demonstrable difference in mortality rate of any one group, regardless of the time interval. An important factor influencing mortality was the degree of shock on admission. One thing which is possibly true but not shown, is that patients developed greater shock as the time interval increased and thus fell into a different group. The number of organs injured all influenced the degree of shock.

Above all else, shock remains the most important symptom or syndrome to be treated and controlled in these severely wounded abdominal cases if mortality is to be lessened.

Wounds of the Colon and Rectum. (Shock on Admission contd)

TABLE IX

Shock in Relation to Time Interval Wounding to Admission

(1140 Colon and Rectum Cases)

	0-6 Hours		6-12 Hours		12-18 Hours		18-24 Hours		Over 24 Hrs.	
	Pts	Died	Pts	Died	Pts	Died	Pts	Died	Pts	Died
None or slight	217	24 11%	101	7 7%	24	1 4%	20	3 15%	21	3 14%
Moderate	199	58 29%	103	24 23%	32	15 47%	11	1 9%	14	7 50%
Severe	225	153 68%	125	84 67%	24	20 81%	12	9 75%	12	8 66%
TOTAL	641	235	329	115	80	36	43	13	47	18

RESUSCITATION THERAPY

(Colon and Rectum Cases)

The resuscitation of these patients began, in most cases, at the Battalion Aid Station and continued as needed at Collecting and Clearing Stations. Until the first hospital was reached, almost no blood was used, plasma usually having been the only substance available. Active shock treatment with blood and plasma was carried on preoperatively and continued throughout the operation. There was rarely any limit to the supply of blood (usually Group "O") and plasma. The following table gives the amounts of blood and plasma used on more than 1100 patients.

TABLE X

Blood (1131 Patients)

	Patients	Units (500 cc)	Average (Unit) Per Patient (cc)	
Living	721	2043	2.83	1415 cc
Dead	410	2122	5.18	2590 cc
TOTAL	1131	4165	3.68	1840 cc

Wounds of the Colon and Rectum. (Resuscitation Therapy contd)

A comparison is made between the average amount of blood and plasma used in patients who survived and in those who died. The statistics for plasma are probably slightly low due to the failure, in some cases, to record that given before hospital admission.

TABLE XI

Plasma (1106 Patients)

	Patients	Units (250 cc)	(Unit)	Average Per Patient (cc)
Living	706	1722	2.44	610 cc
Dead	400	1498	3.75	888 cc
TOTAL	1106	3220	2.91	728 cc

In the immediate resuscitation and preparation of patients for operation, greatest reliance was placed upon the use of blood. It was used immediately and unstintingly. In the earlier cases of this series it was felt that operation should be delayed until shock was overcome to a degree that systolic blood pressure was over 100 mm. As experience was gained there was a general tendency to operate earlier if response to resuscitation was poor and to continue active shock treatment throughout the operative procedure. Thus, much less preoperative time was lost on certain types of patients in whom full resuscitation was notably difficult to accomplish before operation. Such cases were severe right colon injuries, abdominal eviscerations and patients with active abdominal bleeding.

SURGICAL MANAGEMENT OF THE COLON & RECTUM

(1222 Colon and Rectum Cases)

In this series of 1222 patients with wounds of the colon (including rectum), the various surgical procedures utilized may seem to be many, indicating that there is a wide variation of opinion among the surgeons of this Group as to the proper handling of wounds of the large bowel. However, if the types of operations are examined it is found that the opposite is true. The opinion in this Group, as to the proper procedure to pursue in dealing with battle wounds of the colon and rectum, is probably less varied and as definite and concrete as any surgical procedure of the abdomen. The principle of exteriorization

of the injured colon has been closely adhered to throughout the Group. As one would expect, several types of exteriorization of the colon have developed and procedures other than exteriorization have arisen when it was inadvisable or not possible to exteriorize the injured bowel.

In general, all surgical procedures for wounds of the colon and rectum were based on three fundamental principles. First, the exteriorization of the wounded segment of bowel to avoid intraperitoneal leakage from a suture line. The exteriorized, wounded segment may be used as the site for colostomy when indicated. Second, the diversion of the fecal stream away from distal wounds of the colon and rectum. This may be accomplished by any one of several types of colostomies. When this is done for perforations of the rectum, adequate posterior drainage through the fascia-propria is mandatory. Third, the incomplete diversion of the fecal stream as a temporary measure, thus providing gaseous decompression and also bringing the bowel to the surface so that a diversional colostomy may be formed. When performed in the cecum this may be a tube or tangential colostomy which, however, cannot be converted to a diversional procedure.

Table XII shows every type of operation used by this Group in surgery of wounds of the colon and rectum. It is however, most important that a clear understanding of what is meant by the various specific types of operation be established. Therefore, the following are our definitions of the surgical procedures performed on patients with battle wounds of the colon and rectum.

A loop colostomy is the simple exteriorization of a segment of colon through an abdominal incision. The exteriorized segment is maintained by a tube lying across the incision, and under the segment of colon. (See Sketch three of Figure 42).

A spur colostomy is the exteriorization of a segment of colon or the exteriorization of the proximal and distal ends of colon through an abdominal incision and with both limbs of the colostomy sutured together along the anti-mesenteric surface for a distance of three to four inches forming the "spur". The colon is rotated so that the mesentery lies medially. (See Sketch one of Figure 42).

A tube colostomy is the suturing of a rubber tube into the lumen of the colon and bringing the tube out through a small abdominal incision. (See Sketch two of Figure 42).

The operation "closure intraperitoneal and proximal colostomy" indicates that the perforated colon has been repaired and that this portion of the colon has been left in the peritoneal cavity and that a

loop or spur colostomy has been done at a convenient distance proximal to the repaired colon.

A "diversional colostomy" was either a spur or a loop colostomy but was employed proximal to a perforation of the colon or rectum to divert the fecal stream.

The operation of "resection and ileo-colostomy anastomosis" was employed when terminal ileum and ascending colon were resected and the terminal end of ileum was closed and a side-to-side anastomosis of ileum and transverse colon done. This anastomosis was left in the peritoneal cavity but the proximal end of transverse colon exteriorized through a separate incision in the abdominal wall as a "mucus fistula". (See Sketch four of Figure 43). A variation of this procedure was an end-to-side ileo-colostomy with the exteriorization of the proximal end of the colon. (See Sketch eight of Figure 44). A second variation of this procedure was a side-to-side anastomosis of ileum and transverse colon and exteriorization of the distal end of ileum and proximal end of transverse colon through separate incisions in the abdominal wall as "mucus fistulae" (See Sketch five of Figure 43).

"Resection and double barrel ileo-colostomy" is essentially the same as a spur colostomy, the only difference is that one limb of the exteriorization is ileum and one limb is colon (See Sketch six of Figure 43).

"Posterior drainage (or fascia propria drainage) and a proximal colostomy" indicates that in wounds of the rectum, or rectum and sigmoid, there was a coccygectomy done or an incision just lateral to the coccyx, the rectum was freed from the fascia propria for drainage of the perforated rectum (rectum not repaired) and a proximal loop or spur sigmoidostomy done through an abdominal incision. Here again our variation of this procedure was that the perforation of the rectum was repaired after being adequately drained and exposed. This operation is listed as "Posterior drainage, (or Fascia-propria drainage) closure of perforation and proximal colostomy."

The heading "Resection - limbs exteriorized separately", was used to describe those cases in which a segment of colon was resected and the proximal and distal ends of colon were exteriorized through individual abdominal incisions and not as a double barrel colostomy.

Of this series, 13 patients are listed as having "no operation". These patients, with the exception of two, died on the operating table before the colon lesion was dealt with. The two patients that lived developed a pelvic abscess and a fecal fistula respectively and were

treated surgically later.

The term "tangential colostomy" will be referred to and its definition is as follows: An exteriorization of a small area of only the antimesenteric wall of colon through its individual abdominal incision, thus maintaining the continuity of the bowel. (See Sketch seven of Figure 44).

It is the consensus of the Group that the retroperitoneum should always be drained (rubber tissue drain) through a separate incision when it is contaminated. However, the peritoneal cavity was drained only in about 10% of all colon cases.

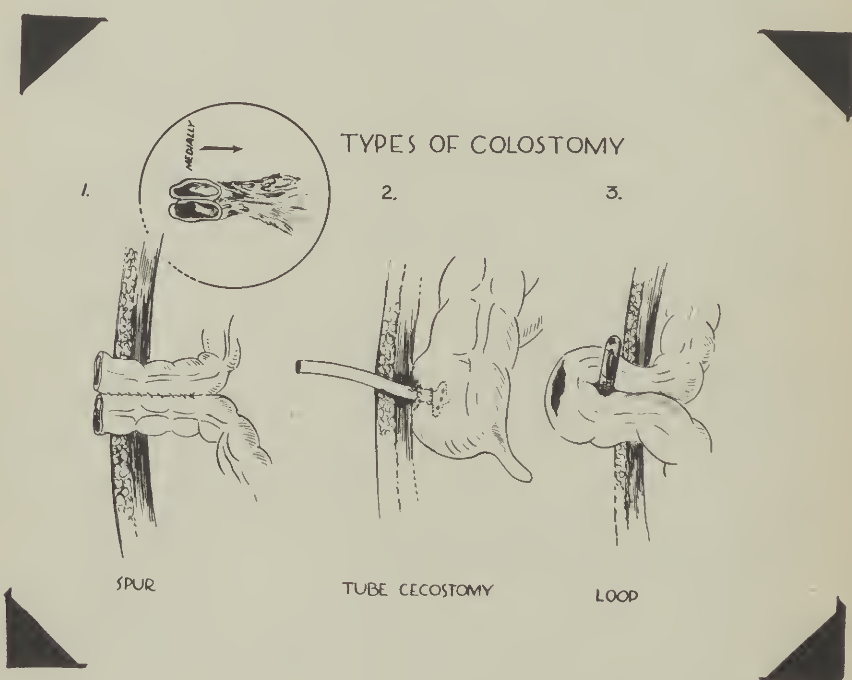


Figure 42. Types of Colostomy.

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum, contd).

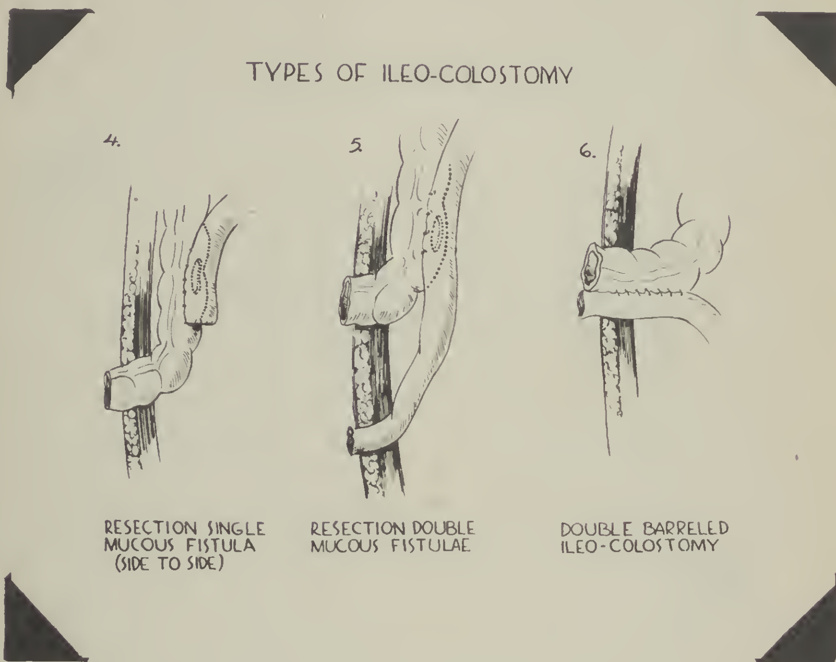


Figure 43. - Types of Ileo-colostomy

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum, contd).

7. 8.

TANGENTIAL COLOSTOMY

RESECTION SINGLE MUCOUS FISTULA (END TO SIDE)

Figure 44 - Types of Ileo-colostomy and Colostomy.

In this series of 1222 patients with perforations or severe damage to the colon or rectum or both, a total mortality rate of 35.4% was found. However, because some of the case records were incomplete, and also due to tactical situations of a fluid battle front it is felt that this mortality rate of 35.4% is somewhat lower than actually existed.

In Table XII various segments and combinations of segments of the colon and rectum are shown with the type of surgical procedures performed and the percent mortality for wounds of the specific segments of the large bowel. As one would expect, wounds of multiple segments of the colon and rectum revealed a mortality rate of about twice that when only a single segment was involved. It is also interesting to note that of 1222 laparotomies on this many patients with wounds of the colon and

rectum, the colon lesion in five patients was overlooked at the time of the operation. Of these five patients, four died and one lived.

TABLE XII

OPERATIONS AND MORTALITY RATE

Colon	Loop	Spur	Tube	Closure (Intra Peritoneal) Colon & Proximal Colostomy	Diver-sional Colost. (No Drain)	Resect Ileo Colost Anas tomosis	Resect Double Barrel Ileo Colost	Post. Drain & Prox. Colost. (Not closed)	Post Drain Closure & Prox. Colost.	Closure No Colost.	Resect. Limbs Exterior ized Separate	No Opera tion	Wound Over looked at Opera tion	TOTAL	DIED	Percent Mortality
Ascending	145	27	39	1		29	17			13	2	6	3	282	87	30.8%
Transverse	252	146	4	1			2			6	3	2	1	417	161	38.6%
Descending	67	48		3						1			1	120	42	35.0%
Sigmoid	82	32		34					4		2	3		157	52	33.1%
Rectum					8			82	25	1				116	27	23.2%
Ascending & Transverse	3	9		6		6	6			2		1		33	19	57.5%
Transverse & Descending	8	29		9							2	1		49	19	38.7%
Ascending & Descending	2	1		6										9	6	66.6%
Colon & Rectum					2		1*	19	17					39	20	51.2%
TOTAL	559	292	43	60	10	35	36	101	46	23	9	13	5	1222	433	35.4%

* Also a loop sigmoidostomy.

Figure 45 - Operations and Mortality Rates

The transverse colon alone was involved in 34% of all cases reported, next in order of frequency of wounds were; ascending colon, 22%; sigmoid 13%; descending colon 10%; rectum (extraperitoneal) 9%; transverse and descending colon 4%; colon and rectum 3%; ascending and transverse colon 2.7%; and ascending and descending colon 0.7%. (See Figure 46).

The appendix was either perforated or transected in 12 patients (1% of total). All of these patients had other and more important abdominal wounds; all were treated by appendectomy.

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum)

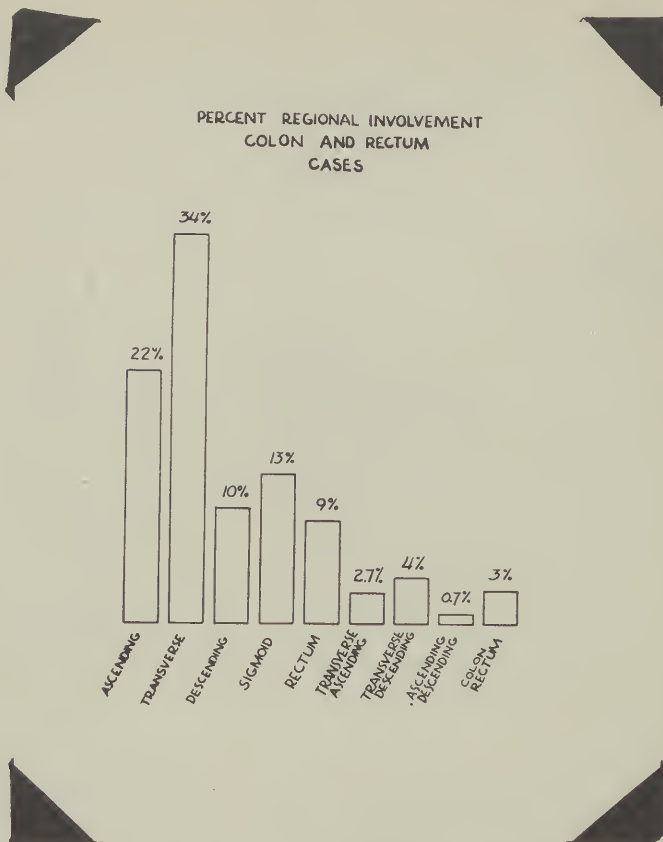


Figure 46 - Percent Regional Involvement Colon and Rectum Cases

Wounds of the ascending colon presented a particularly difficult problem when it was necessary to resect the entire right colon and terminal ileum. Early in the war the most popular procedure was the resection and double barrel ileo-colostomy. This operation was not satisfactory and carried a mortality rate of 64.7%. Later on, resection and ileo-colostomy anastomosis and either double mucus fistulae or single mucus fistula was advocated and was done with some improvement in the mortality rate. However, this mortality rate remained high at 51.7%. Two patients with resection of a portion of the ascending colon had the proximal and distal ends exteriorized separately and both patients died.

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum, contd)

Of interest are the figures that 13 patients had a primary repair of the right colon without colostomy and with only one death. Of course, this indicates nothing because these were the less seriously wounded by far and cannot be considered in any way as being comparable to those patients who required resection of the entire right colon or even those with single large wounds. In 10% of all patients with wounds of the ascending colon a tangential colostomy was done with no deaths. This procedure was done only when the perforation of the bowel was small and on the antimesenteric border of the bowel. The bowel was either repaired and no fecal fistula established at time of operation or the bowel was not repaired and a fecal fistula was present. This group of wounds of the ascending colon was included in the "loop colostomy" type operation of the ascending colon. (See Table XIII)

TABLE XIII

Ascending Colon

Type Operation	Number	Lived	Died	Percent Mortality
Loop Colostomy	145	113	32	22.0%
Spur Colostomy	27	17	10	37.0%
Tube Colostomy	39	29	10	25.6%
Closure Perforation Proximal Colostomy	1	1	0	-
Resection and Ileo-colostomy Anastomosis	29	14	15	51.7%
Resection and Double Barrel ileo-colostomy	17	6	11	64.7%
Closure Perforation No Colostomy	13	12	1	7.6%
Resection Limbs Exteriorized Separately	2	0	2	100.0%
No Operation	6	2	4	66.6%
Laparotomy done Lesion Missed	3	1	2	66.6%
TOTAL	282	195	87	30.8%

The transverse colon was involved in 34% of all colon and rectal wounds of this series. This was by far the most frequent segment involved (See Table V). There were 417 patients with wounds of the transverse colon, with 161 deaths or a mortality rate of 38.6%. Here again there were six patients who had a primary repair of the perforation and no colostomy. There were no deaths in this group of six cases and all of these wounds were comparatively minor. (See Table XIV).

Wounds of the Colon and Rectum. (Surgical Management of the Colon and rectum. contd)

TABLE XIV

Transverse Colon

Type Operation	Number	Lived	Died	Percent Mortality
Loop Colostomy	252	172	80	31.7%
Spur Colostomy	146	74	72	49.3%
Tube Colostomy	4	2	2	50.0
Closure Perforation and Proximal Colostomy	1	1	0	0
Resection and Double Barrel Ileo-colostomy	2	1	1	50.0%
Closure No Colostomy	6	6	0	0
Resection - Limbs Exteriorized Separately	3	0	3	100.0%
No Operation	2	0	2*	100.0%
Laparotomy done Lesion Missed	1	0	1	100.0%
TOTALS	417	256	161	38.6%

*Died on Operating Table.

Wounds of the descending colon presented no unusual problems as compared to wounds of the ascending and lower sigmoid segments. All lesions were dealt with by simple loop exteriorization, or a spur colostomy, or closure of perforation and proximal colostomy. One patient was treated by repair of the perforation and return of the bowel to the peritoneal cavity. The mortality rate was 4% above that for the ascending colon. (See Table XV).

Wounds of the Colon and Rectum (Surgical Management of the Colon and Rectum. contd)

TABLE XV

Descending Colon

Type Operation	Number	Lived	Died	Percent Mortality
Loop colostomy	67	48	19	28.3
Spur Colostomy	48	27	21	43.7%
Closure Perforation and Proximal Colostomy	3	2	1	33.3
Closure No Colostomy	1	1	0	0
Laparotomy done Lesion Missed	1	0	1	100.0%
TOTAL	120	78	42	35.0%

The sigmoid colon presented two problems not present in the colon proximal to the sigmoid. When a perforation of the lower sigmoid was encountered it was quite often impossible to exteriorize the wounded segment due to insufficient distal bowel. In these cases the perforation was repaired and a proximal diversional colostomy was formed (either a loop or spur colostomy). The second problem which was only encountered in four cases was a perforation at the rectosigmoid junction just at the reflection of the peritoneum on the pelvic floor. In these cases the perforation was repaired, a proximal diversional colostomy was done with fascia-propria drainage of the rectum posteriorly, (See Table XVI).

TABLE XVI

Sigmoid Colon

Type of Operation	Number	Lived	Died	Percent Mortality
Loop Colostomy	82	61	21	25.6%
Spur Colostomy	32	18	14	40.6%
Closure Perforation Proximal Colostomy	34	23	11	32.3%
Fascia Propria Drainage-Closure Proximal Colostomy	4	3	1	22.2%
Resection-Limbs Exteriorized Separately	2	0	2	100.0%
No Operation	3	0	3*	100.0%
TOTAL	157	105	52	33.1%

*Died on Operating Table.

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum. contd)

The extraperitoneal rectum was perforated in 116 patients of whom 89 lived and 27 died. In Table XVII, there are eight patients listed as having had only a proximal colostomy (sigmoidostomy), to divert the fecal stream from the rectum. Nothing was done locally to the rectum. The mortality rate for these eight patients was 62.5%.

One patient had the rectal perforation sutured and no proximal colostomy. This patient died.

The remaining patients had proximal diversional colostomy, fascia-propria drainage of the rectum and either closure or no closure of the rectal perforation. The mortality rates were 24% and 18% respectively.

The so-called "fascia propria drainage" is defined as adequate exposure and drainage of the extraperitoneal rectum either by removing the coccyx and freeing the fascia-propria from the rectum or by dissecting the fascia-propria from the rectum and obtaining adequate rectal exposure through an incision just lateral to the coccyx. This type of operation with a proximal diversional colostomy, (either a loop or spur) was done in the great majority of patients with perforations of the rectum.

TABLE XVII

Rectum (Extraperitoneal)

Type of Operation	Number	Lived	Died	Percent Mortality
Diversional Colostomy (only)	8	3	5	62.5%
Fascia-Propria Drainage and Proximal Colostomy	82	67	15	18.3%
Fascia-Propria Drainage-Closure Perforation and Proximal Colostomy	25	19	6	24.0%
Closure, No colostomy	1	0	1	100.0%
TOTAL	116	89	27	23.2%

The mortality rate was noted to increase sharply when two different segments of large bowel were involved. One hundred thirty patients had wounds of either two different segments of colon or colon and rectum. The mortality rate was 49.2%. Tables XVIII, XIX, XX and XXI show the various combination with multiple large bowel segment involvement with the individual mortality rates.

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum. contd)

In these groups of patients with multiple segments wounds of the colon or colon and rectum, 43 patients had two different colostomies established at the site of the colon wounds. Of the 43 patients with two colostomies, 17 died, a mortality rate of 39.5%.

TABLE XVIII

Ascending and Transverse Colon

Type Operation	Number	Lived	Died	Percent Mortality
Loop Colostomy	3	3	0	0
Spur Colostomy	9	3	6	66.6%
Closure Distal Perforation Loop Exteriorization of Proximal Perforation	6	3	3	50.0%
Resection Ileo-Colostomy Anastomosis	6	2	4	66.6%
Closure, No Colostomy	2	1	1*	50.0%
Resection Double Ileo-colostomy	6	2	4	66.6%
No Operation (died on table)	1	0	1	100.0%
TOTAL	33	14	19	57.5%

*Died of pulmonary embolus

TABLE XIX

Ascending and Descending Colon

Type Operation	Number	Lived	Died	Percent Mortality
Double Loop Colostomy	1	0	1	100.0%
One spur one loop Colostomy	1	0	1	100.0%
One Tube and One loop Colostomy	1	1	0	0.0%
Closure of Distal Perforation Loop Exteriorization of Proximal Perforation	6	2	4	66.6%
TOTAL	9	3	6	66.6%

Wounds of the Colon and Rectum. (Surgical Management of the Colon and Rectum. contd)

TABLE XX

Transverse and Descending Colon

Type Operation	Number	Lived	Died	Percent Mortality
Double Loop Colostomy	9	6	3	33.3%
One Spur and One Loop Colostomy	29	18	11	38.0%
Closure Distal Perforation and Exteriorization of Proximal Perforation	9	5	4	44.4%
Proximal Tube Colostomy and Distal Loop Colostomy	1	1	0	100.0%
No Operations	1	0	1	100.0%
TOTAL	49	30	19	38.7%

TABLE XXI

Colon and Rectum

Type Operation	Number	Lived	Died	Percent Mortality
Diversional Colostomy (only)	2	1	1	50.0%
Resection Double Barrel ileo-colostomy and loop sigmoidostomy	1	0	1	100.0%
Fascia-Propria drainage and Proximal colostomy	19	10	9	47.3%
Fascia Propria drainage-closure Perforation and Proximal Colostomy	17	8	9	53.0%
TOTAL	39	19	20	51.2%

INTRAPERITONEAL CHEMOTHERAPY

(940 Colon and Rectum Cases)

There is a striking uniformity in the mortality rate regardless of the intraperitoneal chemotherapy. One is prone to interpret this

as meaning that the chemotherapeutic agents are ineffectual, when used locally. Before any deduction is made, it is necessary to explain that prior to June 1944 it was routine to give intravenous sulfadiazine postoperatively; after this date, penicillin was given intramuscularly at three hours intervals from admission onward. Some surgeons continued the intravenous sulfadiazine in conjunction with penicillin. There is a possibility too, that some surgeons, who used no agent in the abdomen on slightly contaminated cases, did use some on their bad cases. It seems safe to say that intraperitoneal chemptherapeutic agents made no demonstrable improvement in the results.

TABLE XXII

Intraperitoneal Chemotherapy

(940 Colon and Rectum Cases)

	Number Patients	Deaths	Percent Mortality
Sulfanilamide	522	177	33.9%
Penicillin	134	46	34.3%
Sulfanilamide and Penicillin	141	49	34.7%
No Drug	143	47	32.9%
TOTAL	940	319	33.9%

POSTOPERATIVE COMPLICATIONS

(1222 Colon and Rectum Cases)

From records available it is often impossible to make an accurate appraisal of complications which arose postoperatively. Often there was no note after operation except that of the general condition on discharge or a note about a fatality when it occurred. No doubt many more of the important complications are listed than minor ones. Also, it can be assumed that there were many more cases of non-fatal atelectasis and lobular pneumonia than are noted below. Likewise there must have been additional wound infections, minor hemorrhages and even temporary partial obstructions from edema in the areas of intestinal anastomosis.

Wounds of the Colon and Rectum. (Postoperative Complications, contd)

Without additional comment herewith are listed those complications, fatal and non fatal which were noted, each with the number of occurrences:

Peritonitis.	50
Pneumonia.	46
Anuria.	45*
Wound Infection.	30
Atelectasis.	28
Wound Dehiscence. . . .	12
Intestinal Obstruction .	11
Anaerobic Infection. . .	11
Fecal Fistula.	8
Empyema.	7
Secondary Hemorrhage . .	6
Subphrenic Abscess. . .	6
Pelvic Abscess.	6
Pulmonary Edema.	5
Cerebral Embolus. . . .	1
Fat Emboli.	1?

CAUSE OF DEATH

(1358 Colon and Rectum Cases)

In considering the cause of death in these patients suffering from war wounds it is important to remember thatit is difficult in many instances to name one (Primary) cause of death. Many patients have multiple wounds. Some have severe head and extremity wounds and a large percentage have associated chest or thoraco-abdominal wounds. To illustrate the seriousness of the latter complication, 20% of the deaths in colon cases occurred in thoraco-abdominal wounds.

A majority of the fatal cases had post-mortem examination, complete or incomplete, to establish a cause of death. In the others the clinical examination and course, the operative findings and the attending surgeon's opinion were carefully examined and if possible a cause of death listed. In forty cases no cause is known. These are not considered in figuring proportions. (See Table VI, Appendix).

<u>Shock</u>

Forty-four percent were attributed to this cause. These were patients, mostly severely wounded and almost invariably in severe shock on admission, who may or may not have responded fully to adequate pre-operative shock therapy. They were operated upon, but never responded or reacted to even the most heroic postoperative treatment and died,

*The discrepancy between this figure and that used for cases of anuria in all abdominal cases is probably due to the shorter elapsed time used in this series.

usually within 24 hours but occasionally after 36 hours. Whether death was due to shock entirely, the so-called "irreversible" shock, or to a combination of shock and the effects of an overwhelming peritoneal contamination is debatable. Certainly, most of these patients died before a fatal type of bacterial peritonitis could be identified. Just as certainly, there was present in most of these cases sufficient irritative peritoneal contamination in the form of feces, small intestinal contents, bile, blood, or urine to cause a "shock" reaction. Also, the actual loss of blood in these patients was of tremendous importance, along with the other factors, in the causation of this severe and fatal type of shock.

Until more is known about the disturbed physiology and how to control and correct it, this phenomenon will continue to be one of the major factors in the mortality rate.

This type of death was especially prone to occur after operations for extensive wounds involving the right colon, cecum, and lower ileum where the bowel contents are liquid and notably irritative. Constant changes were made in the suggested means of handling these patients because of the high mortality. It seems that the remedy does not lie so much in finding a better operation but in being better able to cope with and alleviate the marked disturbance in physiology.

Intra-Abdominal.

Intra-abdominal causes of death represented 26% (119 cases) of the total and, except for hemorrhage (7 cases), were directly or indirectly due to infection within the abdomen.

Hemorrhage.

Unquestionably in some of the deaths attributed to shock, hemorrhage played an important part. Postoperatively though, hemorrhage was relatively unimportant as a primary cause of death.

Peritonitis.

Ninety, or 20% of deaths had a degree of generalized peritonitis which made it the apparent cause of death. Fatal peritonitis was most frequent in right colon lesions (24% of deaths) and decreased as the lesion was more distal (15% of deaths in sigmoid lesions). It is difficult to suggest how improvement in this rate could be made. No doubt a number of cases died because of an associated lesion which when combined with peritonitis, was overwhelming. Some, it can be imagined,

Wounds of the Colon and Rectum. (Causes of Death , contd)

might have carried over their infection had they had the more individualized treatment which is possible in periods of lessened activity. Peritonitis is a cause of death less to be feared than formerly and one which possibly can be further eliminated by full use of all the means at our command.

From facts at hand, there is no proof that any intraperitoneal chemotherapy influences the mortality rate (See Chemotherapy, Page We are unable to add, except by inference, that it fails to aid in the control and treatment of peritoneal infection. Penicillin has been used routinely since June 1944 and some surgeons have continued to use intravenous sulfadiazine in addition to the penicillin in all colon and rectum injuries.

Retroperitoneal cellulitis.

Retroperitoneal cellulitis has been responsible for seven deaths. Two were extraperitoneal rectal cases and the others were lesions distributed about equally over the entire colon, ascending to sigmoid.

Local abscess.

There were few deaths from this cause reported - only five. The obvious reason is that deaths from subphrenic and other abscess, when they occur, are late and usually in hospitals to the rear. Of the five deaths from abscess, one was in an ascending and four were in transverse colon wounds.

Abdominal "gas" infection.

Apparently no fatal intraperitoneal anaerobic infection has been recognized since the routine use of penicillin. Five deaths from this cause were reported in this series prior to February 1944.

Intestinal obstruction.

There were five deaths from obstruction. All had complicated small bowel lesions which later were the sites of obstruction. In at least two, the obstruction followed a breaking down of small gut anastomosis. Like abscesses, this is a complication occurring late and deaths take place in other hospitals.

Anuria.*

Forty-five patients or 10% of the total died in anuria. In these the kidney lesion was the primary cause of death. No death was attri-

*The discrepancy between this figure and that used for cases of anuria in all abdominal cases is probably due to the shorter elapsed time used in this series.

buted to this cause unless at least three days had elapsed between injury and death. This arbitrary time limit was based upon the generally accepted concept that three days is the minimum time in which fatal renal dysfunction from this cause can occur. Some men set a longer minimum time.

Intrathoracic.

Intrathoracic causes of death made up 14% (63 cases) of the total deaths with known causes. In view of the fact that in 95 deaths (20%) there was thoracic involvement through the diaphragm and in still others there was associated chest injury without perforation of the diaphragm this percentage does not loom large.

Chest injury.

In 11 cases, including four blast injuries, the chest wound was the primary cause of death.

Pulmonary embolus.

Pulmonary embolus caused 16 or 3.5% of deaths.

Pneumonia.

Pneumonia was responsible for only 20, or 4.4% of deaths. This low figure is no doubt made possible by the routine chemotherapy of all wounded patients in addition to the skill of the anesthetists. Certainly, endotracheal anesthesia and tracheobronchial aspirations during and after anesthesia have played an important part in preventing and relieving atelectasis and thus, subsequent pneumonia. Atelectasis caused five and pulmonary edema 10 deaths. There was one death from empyema.

The remainder of deaths were classified MISCELLANEOUS but most important were six due to associated head injury and seven due to soft tissue anaerobic infection. Some of the latter were in buttock wounds in direct communication with rectal and colon wounds but most were in concomitent extremity wounds.

Summarizing, one finds that of all known deaths in this large series of cases, only one in four was due to intraperitoneal infection; two of the four were due to shock or anuria, the immediate effects of trauma; and the fourth was due to complications and, to a lesser degree, to associated injuries. (Data summarized in Table VI, Appendix.)

Wounds of the Colon and Rectum.

SUMMARY AND CONCLUSIONS

1. In a consecutive series of 3532 abdominally wounded patients operated upon by the 2nd Auxiliary Surgical Group, 38.4% had open or gangrenous wounds of the large intestine, including the rectum. The recorded mortality rate was 36.2% in the hospitals of operation.

2. The average time lag from wounding until surgery was begun was 10.9 hours. We believe that preoperative time lag in colon injuries definitely effects the mortality rate adversely. In rectal wounds with no colon involvement there was not the same adverse effect.

3. There was a definite and almost regular increase in the mortality rate proportional to the number of additional abdominal organs injured. This "multiplicity factor" seems to be more important than the nature of the particular organs involved, in determining prognosis.

4. The degree of "shock" on admission was of utmost importance. Sixty-nine percent of the severely shocked patients died; twenty-nine percent of patients admitted in moderate shock died and only 10% of patients in slight or no shock died. The degree of shock closely parallels the "multiplicity factor" of injured abdominal organs, i.e., the greater the number of abdominal organs involved the greater will be the degree of shock.

5. Colon injuries with an associated thoraco-abdominal wound had a 50% mortality and represented 20% of all deaths.

6. The preoperative resuscitation of colon cases in particular should be early and vigorous and should be continued throughout surgery. The average amount of blood received per patient preoperatively was 1840 c.c.

7. Fundamentally the basic principles of colon surgery in war wounds are three: 1) Exteriorization of wounded portions of bowel, whenever feasible to avoid intraperitoneal leakage; 2) Complete diversion of the fecal stream away from distal wounds of the colon and rectum by proximal colostomy, and 3) Incomplete diversion of the fecal stream for gaseous decompression and possible future complete diversion, by colostomy.

8. Simple loop colostomy has been most frequently used. The spur type has been reserved in most cases for resections, transections and large mesenteric border wounds of the colon.

9. Many small antimesenteric perforations of the colon, particularly on the right side may be closed and the closed site exteriorized

tangentially, thus maintaining bowel continuity, without ever forming a fistula. Others may be handled as a tube colostomy.

10. Severe right colon wounds requiring resection are probably best treated by ileo-transverse colic anastomosis with exteriorization of the proximal end of the transverse colon or the variation of this operation in which the distal end of the ileum is also exteriorized through a separate incision. Some surgeons of the Group feel that a spur ileo-colostomy is preferable.

11. Posterior drainage of the peri-rectal space is mandatory in all extraperitoneal rectal wounds in addition to a diversional colostomy.

12. All parts of the colon can be exteriorized except the lower sigmoid and all retroperitoneal portions must be reflected for thorough examination if a wound is suspected.

13. All contaminated retroperitoneal spaces should be adequately drained but it is not necessary to drain the peritoneal cavity in most instances.

14. There is no evidence that intraperitoneal chemotherapy is an effective adjunct to the systemic use of penicillin and sulfadiazine in colon injuries.

15. More than half of the deaths were due to "shock" and anuria ("Shock" 44% and Anuria 10%). It seems reasonable to assume that until more is known about the physiology of shock and more adequate methods of prevention and treatment are employed, the high mortality rate cannot be lowered.

16. Intra-abdominal infection caused 25% of all deaths. The frequency of fatal peritonitis was greatest in right colon lesions and decreased as the lesions were more distal.

APPENDIX

TABLE I

Time Interval - Wounding to Operation (1222 Colon & Rectum Cases)

	0 - 6		6 - 12		12 - 18		18 - 24		24 - 48		48 Plus	
	No. Pts.	Died	No Pts.	Died	No Pts.	Died	No Pts.	Died	No Pts.	Died	No Pts	Died
Ascending	93	25	114	43	33	6	17	3	17	7	8	3
Transverse	119	39	212	87	49	22	19	8	15	5	3	0
Descending	29	6	62	19	17	10	5	3	7	4		
Sigmoid	40	10	69	27	29	11	7	1	11	3	1	0
Rectum (extra peritoneal)	15	5	57	12	23	7	11	1	10	2		
Rectum and colon	7	4	21	11	6	3	4	1	1	1		
Ascending & Descending	3	2	3	1	1	1	1	1	1	1		
Ascending & Transverse	14	7	13	8	5	3	1	1				
Transverse & Descending	16	7	24	7	5	2	1	1	3	2		
TOTAL	336	105	575	215	168	65	66	20	65	25	12	3
PERCENT	31.3%		37.4%		38.7%		30.3%		38.5%		25.0%	

Wounds of the Colon and Rectum. (Appendix contd)

TABLE II

Complicating Abdominal Injury (1222 Colon and Rectum Cases)

	Number of Patients	Deaths	Percent Mortality
Colon alone	251	57	23.0%
Colon and Hollow Viscera	480	176	37.0%
Colon and Solid Viscera	159	55	35.0%
Colon, Hollow and Solid Viscera	177	98	55.0%
Colon and Rectum	13	6	46.0%
Rectum alone	64	9	14.0%
Rectum and Hollow Viscera	72	29	40.0%
Rectum and Solid Viscera	2	0	0.0%
Rectum, Hollow and Solid Viscera	4	3	75.0%
TOTAL	1222	433	35.4%

Wounds of the Colon and Rectum. (Appendix, contd)

TABLE III

Time Lag and Multiplicity of Organs Involved (1155 Colon & Rectum Cases)

		0 - 6 Hrs	6 - 12 Hrs	12 - 18 Hrs	18 - 24 Hrs	Over 24 Hrs	Total
Colon or	Patients	71	120	38	25	38	292
Rectum	Deaths	9	26	6	4	12	57
Alone	Mortality	12.6%	21.6%	15.8%	16.0%	31.7%	19.5%
Colon and	Patients	159	242	79	25	28	533
One	Deaths	45	79	32	6	10	172
Organ	Mortality	22.0%	32.06%	40.5%	24.0%	35.7%	32.3%
Colon and	Patients	67	110	34	14	8	233
Two	Deaths	31	53	17	6	5	112
Organs	Mortality	46.2%	48.1%	52.3%	42.8%	62.5%	48.0%
Colon and	Patients	25	31	7	5	2	70
Three	Deaths	14	12	6	4	1	37
Organs	Mortality	56.0%	38.7%	85.7%	80.0%	50.0%	52.9%
Colon and	Patients	7	13	1		1	22
Four	Deaths	6	10	1		1	18
Organs	Mortality	85.7%	76.9%	100.0%		100.0%	81.8%
Colon and	Patients	1	4				5
Five	Deaths	1	4				5
Organs	Mortality	100.0%	100.0%				100.0%
TOTALS	Patients	330	520	159	69	77	1155
	Deaths	106	184	62	20	29	401
	Mortality	32.1%	35.4%	39.0%	29.0%	37.7%	34.7%

Wounds of the Colon and Rectum. (Appendix contd)

TABLE IV

Shock in Relation to Time Interval Wounding to Admission (1140 Colon and Rectum Cases)

	0 - 6 Hrs		6 - 12 Hrs		12 - 18 Hrs		18 - 24 Hrs		Over 24 Hrs	
	Pts	Died	Pts	Died	Pts	Died	Pts	Died	Pts	Died
None or Slight	217	24 11%	101	7 7%	24	1 4%	20	3 15%	21	3 14%
Moderate	199	58 29%	103	24 23%	32	15 47%	11	1 9%	14	7 50%
Severe	225	153 68%	125	84 67%	24	20 81%	12	9 75%	12	8 66%
TOTAL	641	235	329	115	80	36	43	13	47	18

TABLE V

Related Thoraco-Abdominal Injury (1358 Colon and Rectum Cases)

	Number of Patients	Deaths	Percent Mortality
Ascending Colon	13	9	70%
Hepatic Flexure	22	15	68%
Transverse Colon	76	33	43%
Splenic Flexure	57	30	53%
Descending Colon	23	8	35
TOTAL	191	95	50

Wounds of the Colon and Rectum. (Appendix, contd)

TABLE VI

Primary Cause of Death (1358 Colon and Rectum Cases)

	Number Deaths		Percentage of Deaths From Known Causes
1. "Shock"	200		44%
2. Intra-abdominal			26.2%
a. Hemorrhage	7	1.5%	
b. Intestinal Obstruction	5	1.0%	
c. Peritonitis generalized	90	20.0%	
d. Abscess	5	1.0%	
e. "Gas" infection peritoneal)	5	1.0%	
f. Retroperitoneal cellulitis	7	1.5%	
3. Anuria*	45		10%
4. Intrathoracic			14%
a. Pneumonia	20	4.4%	
b. Pulmonary Embolus	16	3.5%	
c. Pulmonary Edema	10	2.2%	
d. Atelectasis	5	1.0%	
e. Empyema	1	0.2%	
f. Blast Injury	4	0.8%	
g. Severe Chest Injury Primary cause of Death	7	1.8%	
5. Cranial			1.8%
a. Head Injury Primary Cause of Death	6	1.3%	
b. Fat Embolism	1	0.2%	
c. Cerebral Malaria	1	0.2%	
6. Miscellaneous			3.5%
a. Anaerobic Infection	7	1.5%	
b. Injury Extremity, Primary	1	0.2%	
c. No record except primary cause not intra-abdominal	8	1.8%	
Total Deaths From Known Causes	451		
7. Insufficient Information	40		
TOTAL DEATHS	491		

*The discrepancy between this figure and that used for cases of anuria in all abdominal cases is probably due to the shorter elapsed time used in this series.

WAR WOUNDS OF THE LIVER

The present war has offered an opportunity for the critical appraisal of the surgical treatment of liver wounds. In discussions based on World War I experience, hemorrhage from liver wounds usually is considered as the chief cause of fatalities and complications (1, 2 and 4). Our observations, however, point to the complications of bile leakage and hepatic parenchymal damage as of greater significance. Our mode of surgical care has been altered accordingly. The increase in coincidental injury to other abdominal viscera found in these later studies should tend to raise the morbidity and death rates. Surgical management has improved to such a degree in the present war, however, that a significant overall reduction in mortality has resulted (See Table I, Appendix).

The data presented are based on a series of 829 patients with wounds of the liver and biliary tract, taken from a group of 3154 abdominal and thoraco-abdominal cases. Three thousand sixty-six records were available for our analysis at the time it was made. The data necessarily are limited to the forward hospitals in which the initial surgery was performed. Sufficient information pertaining to the outcome of these patients in hospitals to the rear is not available for analysis at this time. Some of the clinical records were incomplete in various details. Certain charts and tables have been based, therefore, on less than the total cases studied.

INCIDENCE

The following table presents the overall incidence and mortality for wounds of the liver in our series, 1944 and 1945:

TABLE I

Wounds of Liver and Biliary Tract - Incidence and Mortality

	1944	1945*	Combined 1944-45
Total Cases (Abdominal and Thoraco-Abdominal Wounds)	2383	771	3154
Cases Utilized	2295	771	3066
Total Cases - Wounds of Liver	646	183	829
Incidence Rate	28.1%	21.3%	26.7%
Total Cases-Wounds of Gall Bladder or bile ducts (liver involved in all cases)	40	13	53
Percentage, Wounds of Gall Bladder	1.7%	1.7%	1.7%
Fatal Cases, Total	193	31	224
Mortality Rate, Total	29.8%	16.9%	27.0%

*Covers period 1 January to 8 May 1945 inclusive.

War Wounds of the Liver. (Incidence contd)

Abdominal wounds comprised 46.2%, and thoraco-abdominal wounds 53.8% of all wounds involving the liver (See Table VIII, Appendix). It is interesting to compare the incidence of liver wounds in this series with available statistics for World War I (Table I, Appendix). Restricted to liver involvement in abdominal wounds only the World War I incidences of 13.3% and 16.8% respectively are seen to agree fairly closely with our incidence of 17.1%.

MORBIDITY AND MORTALITY

The overall mortality rate for wounds of the liver in our series was 27.0% as contrasted to a mortality rate of 66.2% in World War I. The number of viscera involved in association with the liver wound represented the most important single factor in prognosis. As shown in Table II,(Appendix) mortality was directly proportional to the number of other viscera wounded. Uncomplicated wounds of the liver had a mortality rate of 9.7%. The mortality rate when the liver and one other organ were injured was 26.5%. But the mortality rate rose to 84.6% when the liver and four or more other viscera were wounded. (See Figure 47).

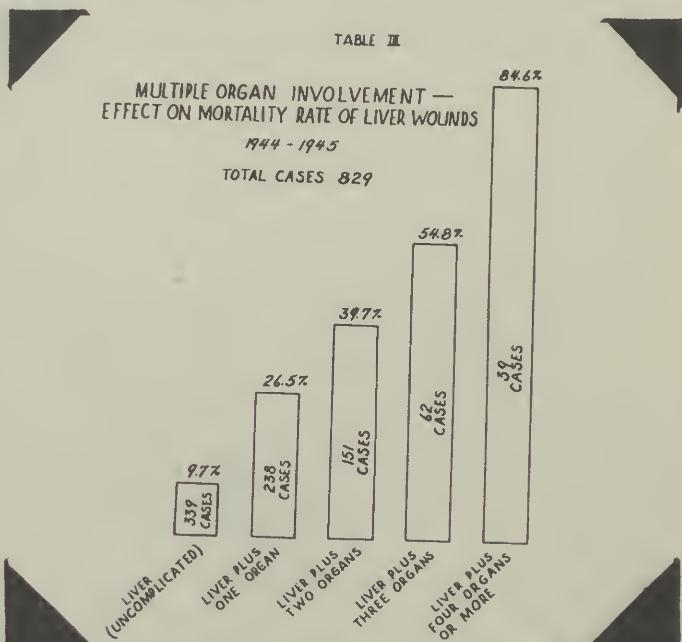


Figure 47 Multiple Organ Involvement, Effect on Mortality Rate of Liver Wounds.

War Wounds of the Liver (Morbidity and Mortality contd)

From Table III, (Appendix), it will be seen also that when the liver was injured in association with the colon only, the mortality rate was the greatest for any single organ-liver combination (32.3%). The second most serious combination was that in which the liver and the stomach-duodenum were involved, (31.3%). These relationships are graphically represented in Figure 48)

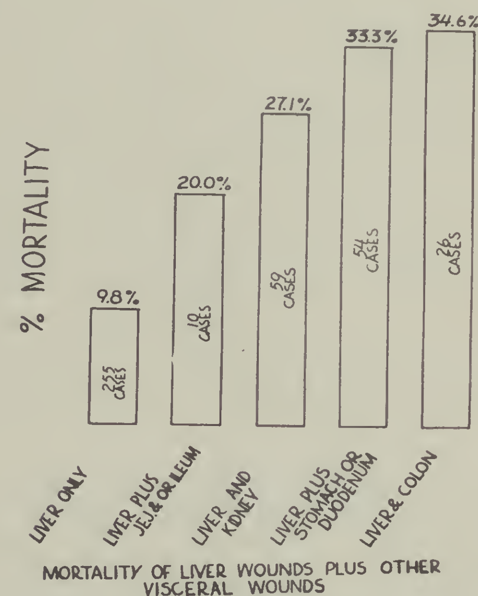


Figure 48- Mortality of Liver Wounds Plus Other Visceral Wounds.

The location of the wound is important because of the proximity to other organs. Wounds about the hilum of the liver occasionally involved the extra-hepatic bilary ducts, retroperitoneal duodenum, pancreas, stomach, colon, or vena cava. These complicated wounds carried a high mortality rate. During the year 1944, 558 records defined the location of liver wounds with sufficient accuracy for use in this s tudy:

War Wounds of the Liver. (Morbidity and Mortality contd)

TABLE II

Anatomical Site of Liver Wounds in 558 Cases

Lobe of Liver Involved	Number of Cases	Percentage
Right lobe	446	83.5%
Left lobe	73	13.1%
Both lobes	19	3.4%

The extent and location of the liver wound are of importance. However, a small penetrating wound may be followed by more serious complications such as bile leakage or hemorrhage than one in which a larger mass of liver tissue is involved. The majority of cases, 76%, fell into Grade I or II on a basis of I, II, or III Grades of severity. They were most often described as a lacerating, penetrating or perforating wound, small or moderate in degree. Twenty four percent of the group were described as "severe wounds" (Grade III) and on some occasions required resections of a part of a lobe, even the entire left lobe. Bleeding from the liver had ceased at the time of exploration in 91.1% of the cases. In the remainder it was rarely described as severe. In no case of this series was death ascribed to bleeding from the liver during the postoperative period in the forward hospitals.

It was impossible to evaluate the amount of bile in the peritoneal cavity. Usually some bile leakage had occurred, but the presence of much intestinal content plus exudate and blood made even a rough estimate unsatisfactory.

There are certain associated factors which may have influenced the morbidity and mortality in this group although difficult to prove statistically. The wounding agent, time lag from injury to surgery, the availability of adequate shock treatment and the use of sulfonamides and penicillin all played varying roles. It is known also that the mortality in this group of cases was higher in winter months when the incidence of pulmonary infection was high.

OPERATIVE INCISIONS

Location of operative incisions in these cases is given in Table V, and was as follows: Abdominal (47.2%); Thoracic (36.3%); both (12.5%). The incision frequently varied with the amount of visceral injury in any given case and in particular whether thoracic or abdominal viscera or both, were involved. An increase in the transdiaphragmatic approach is apparent in the 1945 group. With increased experience the surgeons found the results to be better when this approach could be utilized. "Thoraco-laparotomy" was performed in seven cases. If, in this incision, the thoracic wound is extended down over the anterior chest wall into the abdomen, cutting the

chondralarch in its course, complications may follow. Such wounds become infected easily and tend to break down, resulting in difficult treatment problems. If the abdominal pathology encountered in a thoraco-abdominal wound cannot be handled adequately through the initial thoraco approach, we believe a separate laparotomy incision should be used rather than cutting across the costal arch.

SURGICAL TREATMENT

A tabulation was made of the various types of surgical treatment of the liver wound itself (Table III). Nearly 58%of all cases tabulated (695) were treated by placement of drains only, 28.2% by packing, 5.3% by suture of the wound plus drainage, and 7.8% without local treatment. Of more significance, however, is the change in these modes of treatment with increased surgical experience. The use of drains alone rose from 48.5% in 1944 to 87.4% in 1945, with a corresponding reduction in use of the liver pack from 34.1% to 9.6%. There was also a sharp decrease in the number of liver wounds left without any treatment in 1945, though the total number of such cases was small.

TABLE III

Types of Surgical Treatment

	1944	1945	Combined 1944-1945
Total cases tabulated	528	167	695
Type of Treatment:			
Drain (s)	48.5%	87.4%	57.8%
Pack	34.1%	9.6%	28.2%
Suture (and drain)	6.5%	1.8% (3 cases)	5.3%
Suture and pack	0.95% (5 cases)	.0%	-
Muscle graft	0.15% (1 case)	.0%	-
No treatment	9.8%	1.21% (2 cases)	7.8%

Comment: The trend in treatment away from packs to simple external drainage in 1945 is well illustrated here. It parallels an improvement in mortality rate for that year. (See Table I, Text).

CAUSES OF DEATH

Table V (Appendix), enumerates the principal causes of death. Autopsies were performed on a majority of the cases which died in the forward hospitals, and, in most instances, by the operating surgeon. "Shock" was listed as the chief cause of death in 51.4% (115 cases). This diangosis represented a state of persistent circulatory collapse and none of the cases so listed survived beyond the second postoperative day. Blood loss appeared to be only one of several factors contributing to the shock. A multiplicity of factors including disturbances of cardio-respiratory physiology, overwhelming contamination of the peritoneal and pleural cavities, tissue destruction and widespread retroperitoneal cellulitis all played significant roles.

Pulmonary complications represented the second most important group of causes of death. There were 38 such cases, 17% of the total group of fatalities. Trauma to the diaphragm in over half of all liver wounds, trauma to the lung, bile contamination of pleural cavities and prolonged other anesthesia provided ample background for pulmonary complications.

Some degree of peritonitis existed in all the fatal cases. When listed as a cause of death, it implied either a widespread or marked local process (such as subphrenic abscess).

Oliguria and renal failure represented the chief cause of death in 19 cases (8.5%). It is interesting to speculate on the possible relationship of liver damage to renal failure though we could not eliminate "transfusion" or "shock kidney" as the basic pathology in most of these cases.

A miscellaneous group of causes of death: gas gangrene; head injury; paralysis following wound of spinal cord; and others, totalled 10.7%, (24 cases). Causes of death for the year of 1944 only, are portrayed graphicallyin Figure .

War Wounds of the Liver. (Causes of Death contd)

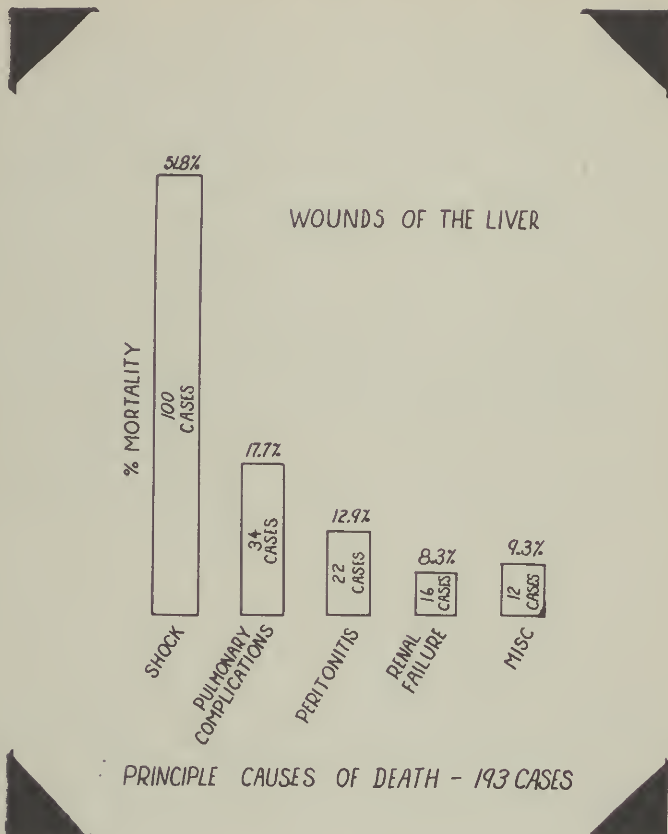


Figure 49- Principal Causes of Death - 193 Cases

Extra-Abdominal Wounds.

Coincidental wounds outside of the abdominal cavity undoubtedly exerted on effect on morbidity and mortality in this series. These included frequent injury to the lung, occasional trauma to the heart, and, in every thoraco-abdominal case, wounds of the diaphragm and thorax. Several instances of spinal cord wounds contributed to mortality also. The significance of peripheral wounds such as compound fractures of long bones, traumatic amputations or head wounds could not be evaluated separately.

Wounds of the Gall Bladder and Bile Ducts.

Fifty-three wounds of the gall bladder and bile ducts (51 gall

bladders, 2 common ducts) were included in this series and represented 6.3% of total liver and biliary system or 1.7% of all abdominal and thoraco-abdominal wounds. In every case, the gall bladder or bile duct wound was complicated by a wound of the liver. Because of this circumstance and the frequent occurrence of wounds of other abdominal viscera in these cases, it was impossible to evaluate their significance in the morbidity and mortality rates. In general, however, the mortality for cases exhibiting wounds of the gall bladder and bile ducts has been 30%, corresponding closely to the overall mortality rate of 27.0% in liver wounds. The degree of damage to the gall bladder varied greatly. In one case the fundus was partly avulsed from its bed without direct damage to the gall bladder wall. Simple suture sufficed to repair this damage. In 5 instances small wounds of the fundus were closed with purse string sutures. The balance of 47 cases was about equally divided into severely lacerated gall bladders requiring cholecystectomy and less severe wounds treated by tube cholecystectomy. One of the two common duct cases sustained a wound of the duct near the ampulla of Vater. This was overlooked at operation and undoubtedly contributed to the death in this case. In the other case the common duct was perforated in the hepatico-duodenal ligament. Simple suture without drainage was followed by recovery.

DISCUSSION

The large number of liver wounds encountered in this war and the frequency of complications following some methods of treatment have directed our attention to a more critical appraisal of the important problems. In the past, the chief concern in the treatment of liver wounds has been the control of hemorrhage. It is our belief, based upon this large series of cases, and our own personal experiences, in both forward and base hospitals that bleeding is not the most important feature. In only 9% of this large group of cases was active bleeding present at the time of exploration. In 91% of the cases, therefore, spontaneous hemostasis had occurred by the time of operation. The chief sources of bleeding in any liver wound are from the hepatic artery, which enters the porta of the liver, divides into its branches, and from the portal vein which similarly enters at the liver porta and immediately branches into small ramifications. Unless a hilar injury is sustained or a missile penetrates deep into the liver, serious bleeding should be rare. The larger branches of the portal vein extend nearer the surface than do those of the arterial system, but the pressure in the venous system is low (8-10 mm Hg.), and bleeding from these vessels can be controlled readily as described later in this discussion. In this series of liver cases, only one instance of serious postoperative bleeding was recorded and this is reported in detail.

War Wounds of the Liver.

CASE REPORT

An American soldier was wounded by high explosive shell fragments, 29 January 1945, with injury to the right costo-phrenic sulcus and the hilar region of the liver. Under gas-oxygen-ether anesthesia the wound was debrided and enlarged and a shell fragment, and bits of clothing were removed from the liver wounds. Penrose drains were placed and brought out through a separate drainage incision. There was copious drainage of old blood and bile for 36 hours after operation. The general course was uneventful however, until the eighth postoperative day, when a severe hemorrhage occurred through the drainage incision. This ceased spontaneously. On the ninth postoperative day a second severe hemorrhage occurred and a gauze pack was inserted deeply into the liver wound through the enlarged drainage incision. There was no sign of infection in the liver substance or adjacent structures at this time. A third hemorrhage ensued. After replacement of the pack by a fresh one this bleeding stopped.

The patient developed chills and fever (pack still in place) on the 16th postoperative day.

The temperature spiked to 105.8 F on the 17th postoperative day, and another severe hemorrhage about the pack occurred. Under pentothal anesthesia, the external wound was reopened and the wound in the liver exposed by incision with the actual cautery to a depth of seven cm. There was found a large artery which had been partly severed by the original injury. This vessel was clamped and ligated, and the liver wound was drained with Penrose drains.

On the 18th postoperative day severe abdominal distentsion developed. On the 22nd postoperative day, bile drainage became very profuse and on the 32nd postoperative day, a liver abscess was drained.

A pelvic abscess was drained the 41st postoperative day and a subhepatic abscess was drained the 51st postoperative day. The patient was making a satisfactory convalescence on the 75th postoperative day.

<u>Analysis of the Case by The Operating Surgeon.</u>

"1. The original thoracotomy was justified by the apparent location of the wound track and the clinical signs of intra-abdominal injury.

2. The foreign bodies were removed from the liver readily, and the increased oozing of dark blood which followed seemed insufficient to require any special hemostatic measures.

3. The hemorrhages on the eighth and ninth postoperative days were massive and obviously arterial. This may have been due to re-opening

War Wounds of the Liver. (Case Report contd)

of the partially severed artery as the surrounding clot retracted. Perhaps the insertion of the first pack on the morning of the ninth day was justified as an attempt at control by conservative means. In retrospect, I think it would have been wiser however not to have packed the wound when hemorrhage reoccurred, but to have explored the bleeding area directly at that time. The known location of the wound in the hilum and the degree of hemorrhage, requiring a large pack to stop it, even temporarily, probably were adequate indications for re-operation.

4. There was no local or systemic evidence of infection at the time the packs were first inserted (nine days after wounding). Seven days later, however, established infection was evidenced by chills and fever up to 105.8° F. I feel certain that the packs were instrumental in causing this infection by damming back drainage. Later difficulties (secondary venous bleeding, liver abscess, subhepatic and pelvic abscess) apparently were complications of this infection. These complications might have been avoided had the source of bleeding been approached immediately in preference to the attempt of conservative control by packing."

It is our opinion that the establishment of adequate external drainage of both bile and tissue products from the traumatized region is the most important feature in the surgical care of liver wounds. Any method that will satisfactorily accomplish this should be followed by good results. The dry pack, the treatment agent most frequently recorded in the literature, will not function satisfactorily as a drain. Advocacy of the liver pack wa s based on the assumption that bleeding from the liver was the chief factor which determined the prognosis. In view of our recent experience, we know that this is not the case. It is true that in a small number of cases (9%), the liver was bleeding at the time the abdomen was explored. Some have recommended suture alone or in association with a muscle stamp for its control. As shown in Table III, above, relatively few liver wounds were sutured by surgeons of this Group and apparently without regret, for the practice was nearly abandoned in 1945. It has been our observation, as well as that of some others, that the bleeding which occurs following suture of the liver may exceed that which existed prior to such treatment. In one interesting case active oozing from a large superficial wound of the right lobe of the liver was observed at the time of operation. Dry gauze was packed against the bleeding area until the remainder of the abdominal pathology was cared for. Before closing the abdomen, the pack was removed and it was found that all the bleeding had ceased. Such use of the pack will occasionally be found worthwhile.

The number of complications of liver wounds seen in Field Hospitals is small when compared with those in hospitals further to the rear. A report (5) from a chest center at a General Hospital offers a better indication of the frequency of these complications. In a series of 98 wounds of the liver which had received their primary operative treatment at forward hospitals, Burford found that 25% presented complications.

War Wounds of the Liver. (Discussion contd)

These were complications resulting from inadequate drainage and included fourteen cases of subphrenic abscess, five cases of bile empyema, and six cases of intra-hepatic abscesses.

A gauze pack does not function as an adequate drain. The pack, whether used alone or in conjunction with drains tends to act as a tampon and may cause one or more complications, such as subphrenic, sub-hepatic or pelvic bile collections and abscesses.

The diaphragm was perforated, of course, in all the thoraco-abdominal wounds (53.8% of all wounds in our series). The bile and exuded fluids, prevented from draining externally by the liver pack have on occasions, forced their way through the sutured diaphragmatic wound. This has been followed by a bile empyema or bilary thoracic fistula. This complication was seen in different cases regardless of the type of closure of the diaphragm. In one instance, the lung was aherent to the suture line of the diaphragm, and the bile eroded through into a bronchus creating a very serious problem. Occasionally the bile not only eroded the sutured diaphragm, but, after reaching the pleural cavity, also caused a breakdown of the thoracotomy incision. Sub-phrenic pleurocutaneous-fistulas resulted. Intra-hepatic necrosis, abscess, hepatitis, and bile peritonitis have all been observed in cases treated with gauze packs. A less important but significant feature is the pain associated with the removal of a large liver pack. It occasionally necessitated the use of an anesthetic, thus adding to the postoperative problem.

Secondary hemorrhage following the removal of a pack may occur. An autopsy on a patient who sustained a fatal secondary hemorrhage following the removal of a liver pack on the 18th postoperative day at a General Hospital was observed by one of the surgeons of this Group. Vascularization had occurred in the liver bed as a reaction to the pack. The granulation tissue which had invaded the meshes of the gauze bled profusely when the pack was removed. The patient became exsanguinated before surgical intervention could be undertaken.

In an effort to obviate the above, early removal of the pack has been practiced in some cases with resultant premature closure of the external drainage wound. Attempts at replacement of the gauze pack by a Penrose drain have been unsuccessful. It is impossible to place the drains adequately except under direct vision at the time the abdomen is opened.

Because primary bleeding from the liver is rarely serious and because the complications following the use of gauze packs have been so numerous, we believe their use should be discontinued. Adequate control of bleeding, when it occurs, almost always can be obtained by the use of a temporary gauze pack during operation or by insertion of the wick end of the Penrose cigarette drain loosely to act as a clot supporting

War Wounds of the Liver. (Discussion contd)

surface. In addition to the control of the bleeding this will provide adequate drainage. A penrose or a Penrose cigarette drain should be placed over the liver dome to the involved area. If large or separate wounds are present two drains are led to this space. A Penrose drain is placed laterally to the postero-inferior margin of the liver obviating a collection in this region. The sub-hepatic space is drained also. All drains are delivered through a dependent drainage incision, usually placed sub-costally, in the anterior or mid-axillary line. This drainage incision must be at least one and one-half inches in length and cleanly incised through all layers of the abdominal wall. A large skin incision and a small opening in the deep layers is inadequate. If all layers are not widely opened, the drains will be strangulated and the drainage function will be defeated. Liver drains should not be brought to the exterior through the laparotomy or thoracotomy incision, since this leads to a higher incidence of wound infections and disruptions. A debrided wound tract coinciding with the usual subcostal drainage incision location may be satisfactory.

The proper removal of the drains holds as important a place in the treatment of the liver wounds as does their initial placing. The shortening must be gradual beginning usually on the 4th or 5th postoperative day. The drains are out completely, preferably by the 10th to 12th postoperative day, though complete removal should be deferred until drainage has virtually ceased. Frequently such a staged removal of Penrose cigarette drains becomes difficult due to the adherence of the gauze wick to the liver bed. Because the free outer ends will stretch before the inner ends are moved, the sudden "give" following traction or twisting of the drains may withdraw the drains too far; fluid collections are thus likely to become pocketed in the liver region. To obviate such a possibility we use drains in which the tendency to stretch has been eliminated. This is done by simply threading surgical tape through the Penrose tubing and anchoring the tubing to it, at intervals of three to four inches, by means of silk suture. Thus, when one withdraws the free outer end of the drain an inch, the inner end is withdrawn a like distance.

It is important that the primary method of treatment of the liver wound afford adequate external drainage. If the liver wound is not adequately drained and becomes infected, a draining sinus may result which will take many weeks to close. One rarely encounters a liver wound which is too small to require drainage. It is true that some cases will not drain bile postoperatively but we know of no criteria by which such cases can be selected preoperatively or at operation. The size of the missile is not the all important factor. A small foreign body which cuts a main bile passage may be followed by a greater drainage of bile than a superficial liver wound of greater proportions. For this reason, we feel that all liver wounds should be explored and adequate external drainage established.

War Wounds of the Liver.

SUMMARY OF FINDINGS

1. A large series of wounds of the liver representing the collective operative experience of the 2nd Auxiliary Surgical Group, for the period 1 January 1944 to 8 May 1945, has been studied.

2. In a grand total of 3154 abdominal and thoraco-abdominal wound cases (3066 records available for this study), 829, or 26.7% manifested wounds of the liver. The derived data apply only to the period of stay in the forward hospitals where the operation was performed. These liver wounds were found divided almost equally into the abdominal and thoraco-abdominal wound categories.

3. Overall mortality rate for wounds of the liver in this series was 27.0% (Table I). Coincidental wounding of other abdominal viscera was found to be a highly important factor in prognosis. The mortality rate for wounds of the liver in absence of other abdominal visceral injury was only 9.7% in contrast to a rate of 84.6% when four or more other abdominal viscera had been wounded also (Table II, Appendix).

4. This study and our personal experience indicate that continued bleeding from liver wounds following operation has not been a potent cause of morbidity and mortality. Bile leakage and liver parenchymal damage appear to have been factors of greater importance.

5. The traditional "pack" for liver wounds has been unnecessary in most cases. Its use has led to serious complications.

6. Operative exploration of all liver wounds with establishment of adequate external drainage is advocated as the most satisfactory mode of treatment.

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APPENDIX

DATA ON WOUNDS OF LIVER

Operated Cases

1944 - 1945

2ND AUXILIARY SURGICAL GROUP

TABLE OF CONTENTS

Appendix.

TABLE I

Wounds of the Liver

Comparative Statistics from Two Wars

(Restricted to Abdominal Wounds Only)

	World War I		World War II			
	Surg. General Reports (1)	Wallace British (3)	2nd Aux Surg Gp 1944	1945	Combined 1944 1945	
1) Percentage of Abdominal Wounds With Liver Involved	13.3%	16.8%	18.5%	12.6%	17.1%	
2) Operative Mortality of Liver Wounds	66.2%		34.0%	15.1%	27.9%	

Comment: Although the incidence of liver involvement in abdominal wounds for two wars was quite similar, there has been a sharp drop in operative mortality rates in World War II. This comparison is only approximate since the World War I figures may not include some liver wound cases treated without operation. A further error is introduced by the fact that no follow up data are available for World War II mortality rates.

TABLE II

Multiple Organ Involvement

Effect on Mortality Rate of Liver Wounds

	1944	1945	Combined 1944-1945
Total Liver Wound Cases.	646	183	829
Mortality Rates:			
1) Overall Mortality	29.8%	16.9%	27.0%
2) Liver (uncomplicated)*	9.8%	9.5%	9.7%
3) Liver plus other abdominal organs (combined)	42.7%	23.0%	38.5%
a) Liver plus 1 other organ	29.1%	15.2%	26.5%
b) Liver plus 2 other organs	43.9%	25.7%	39.7%
c) Liver plus 3 other organs	60.0%	33.3%	54.8%
d) Liver plus 4 or more other organs	90.9%	50.0%	84.6%

*"Uncomplicated liver wounds" refers to liver wounds uncomplicated by wounds of other abdominal viscera. Coincidental wounds of other portions of the body may be present in such cases.

Appendix.

TABLE III

Effect of Injury to Certain Other Abdominal Organs

On Mortality of Liver Wounds 1944 - 1945

Name of Viscera	No. of Deaths	Deaths	Mortality
1) Liver Only	339	33	9.7%
2) Liver Plus Stomach-duodenum	64	20	31.3%
3) Liver Plus Jejunum-ileum	15	2	13.3%
4) Liver Plus Colon	34	11	32.3%
5) Liver Plus Kidney	77	20	25.9%

Appendix.

TABLE IV

Location of Operative Incisions

432 Cases Studied

	1944		1945		Combined 1944 - 1945	
	No.	Pct.	No.	Pct.	No.	Pct.
Abdominal	172	53.5%	42	39.3%	214	47.2%
Thoracic	107	32.6%	50	46.7%	157	36.3%
Abdominal and Thoracic	40	12.0%	14	13.1%	54	12.5%
"Thoraco-Laparotomy"*	6	1.9%	1	0.9%	7	1.6%

*Extension of thoracotomy incision across costal arch and into abdomen usually.

Comment: Note the increase in use of the thoracic approach in 1945.

Appendix.

TABLE V

Principal Causes of Death

Total Deaths - 224 Mortality Rate - 27.0%

	1944	1945	Combined 1944 - 1945
1) Shock	51.8%	48.4%	51.4%
2) Pulmonary Complications	17.7%	12.9%	17.0%
3) Peritonitis	12.9%	9.7%	12.5%
4) Renal Failure	8.3%	9.7%	8.5%
5) Other Causes	9.3%	19.3%	10.7%

Comment: Persistent shock was responsible for approximately half the deaths despite vigorous anti-shock treatment combined with early operation and a minimum of transportation of the case.

TABLE VI

Abdominal and Thoraco-Abdominal Wounds Involving Liver

Comparative Incidence and Mortality

	Incidence						Mortality					
	1944		1945		Combined		1944		1945		Combined	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Abdominal Wounds	311	48.2%	72	39.3%	383	46.2%	106	34.0%	11	15.1%	117	30.5%
Thoraco-Abdominal Wounds	335	51.8%	111	60.7%	446	53.8%	87	25.9%	20	16.2%	107	23.9%

INJURIES OF THE SPLEEN

A review of injuries of the spleen in this series reveals experiences contrasting sharply with those previously reported. An analysis of the 3154 abdominal and thoraco-abdominal injuries managed by the members of this Auxiliary Surgical Group demonstrates a marked divergence from the very limited reports and opinions concerning battle injuries to this viscus. These differences appear in the incidence of involvement, the operative approaches employed, the operative findings, the frequency of complicating lesions, the treatment, and the mortality rate.

The following table of injuries to the spleen shows the total number, the number of uncomplicated and complicated cases, and the incidence and mortality of each.

TABLE I

Number, Incidence and Mortality of Splenic Injuries

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. of Cases	Incidence in 3154 cases	Mort. Rate (gross)	No. of Cases	Incidence in 341 cases	Mort. Rate	No of Cases	Incidence of cases	Mort. Rate
341	10.8%	24.9%	100	29.3%	12%	241	70.6%	30.3%

In this discussion the term "complicated" will be reserved to indicate injury to intra-abdominal viscera other than the spleen, whereas "associated" will be used to indicate the presence of concomitant extra-abdominal injuries.

INCIDENCE

The spleen was involved in a surprisingly large number of instances in the total abdominal and thoraco-abdominal wounds included in this report. Among the total 3154 cases, injury to this organ occurred 341 times, an incidence of 10.8%. Reports of wounds incurred by the American Expeditionary Forces in World War I [1], included only 49 instances of injury of the spleen. No record of its incidence of injury in the Spanish Civil War is available, but Jolly[2] states that uncom-

Injuries of the Spleen. (Incidence, contd)

plicated wounds of the spleen are very rare. An estimated incidence of 5.6% was reported by Bailey[3] and only 54 cases were included. Giblin[4] reported splenic injuries in three instances of 90 abdominal wounds operated upon in the Alamein Campaign. In the two periods covered by Ogilvie's[5] report on abdominal wounds in the Western Desert in 1942, splenic injury occurred in 29 instances giving an incidence of 4.6%. Jarvis[6] reported splenic injury occurring 22 times in 346 unselected abdominal wounds that were managed by the members of this Group, giving an incidence of 6.5% (These cases are not included in this report).

The predominant number of the splenic injuries in this series occurred in thoraco-abdominal injuries. Two hundred fifty-three, or 74.1% occurred in these as compared to 88, or 25.9%, in abdominal injuries. (See Appendix, Table II). The left diaphragm as reported in the section on "Thoraco-abdominal Wounds" (Pages 566 and 591) was involved in 468 instances in all the thoraco-abdominal injuries. Thus the spleen was injured in 54% of the instances that the left diaphragm was involved.

CAUSATIVE AGENTS

Agents causing injury to the spleen were of the same type and essentially the same frequency as those encountered in abdominal injuries in general. (See Appendix, Table III). Blast was recorded as the cause on three occasions. Four instances of splenic injury were non-battle in origin. Two of these were incurred in accidental falls, one in a vehicular accident, and one in a penetrating wound by the metal loop of a cartridge belt.

TYPES OF INJURY TO THE SPLEEN

The spleen showed all degrees of damage from a small fissure to complete fragmentation of the body. A few instances of penetration of the organ were noted. Severe lacerations, penetrations, or perforations produced essentially the same gross pathology as fractures of the organ, that is, irregular rents in the capsule radiating from the tract of the causative agent. Injury to the splenic pedicle alone occurred eight times and subcapsular hamatoma three. Dividing the injuries into slight, moderate, and severe; 61% were in the last mentioned classification; 29% in the moderate, and only 9% in the slight. (See Appendix, Table IV).

Active hemorrhage from the injured spleen was encountered at the beginning of abdominal exploration only in rare instances. When it was encountered, it was always from a severely damaged body of the organ or an injury to the pedicle. Active bleeding usually recurred during the handling of the organ at splenectomy. In cases other than those in which the splenic injury was slight there was always evidence of previous hem-

orrhage. In some thoraco-abdominal cases with splenic injury there was little blood encountered in the peritoneal cavity. However, in such instances a severe left-sided hemothorax was often present. This was likely due to the sucking up of the blood by negative intrapleural pressure through the diaphragmatic rent. This occurred so often that injury to the spleen was suspected where there was a large hemothorax and wounds of entry or exit in the lower part of the left chest.

CLINICAL FINDINGS

Shock was the most common physical finding in injuries of the spleen, but the absence of clinical shock by no means proved to be an indication of the absence of such an injury. Clinical shock was recorded as being absent on admission in 23% of the injuries involving the spleen, 30 of these instances being in uncomplicated cases. Shock classified clinically as moderate and severe was noted on admission in 58% of these cases, and mild shock was present in 12%.

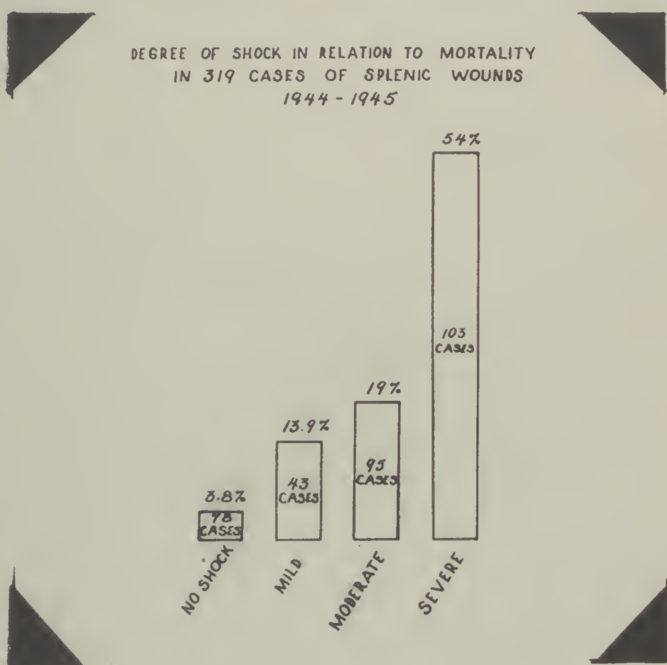

Figure 50 - Relation of Degree of Shock to Mortality in Splenic Injuries

Injuries of the Spleen. (Clinical Findings) contd.

Tenderness in the left upper abdominal quadrant and muscle defense was always present. Referred pain to the left shoulder and base of the neck was not often present.

As noted above, severe left-sided hemothorax was common in thoraco-abdominal cases with splenic involvement.

UNCOMPLICATED SPLENIC INJURIES

The spleen was the sole viscus involved in 100 or 29.3% of the total wounds involving this viscus. However, this is a slightly lower figure than previously reported. Jolly[2] states that uncomplicated injuries are "rare", Bailey[3] reports 59.3% uncomplicated cases in a total of 54. One-third of the 49 splenic injuries reported in the American Expeditionary Forces in World War I were complicated[1]. Jarvis[6] reported 36% of the total 22 cases as uncomplicated. Eighty-two of the uncomplicated splenic lesions in this series occurred in thoraco-abdominal cases, an incidence of 82%.

COMPLICATING VISCERAL INJURIES

Two hundred forty-one, or 70.6% of the total incidence of injury to the spleen showed complicating visceral injuries. In order of their frequency of occurrence, they were the stomach, the colon, the left kidney, the small intestine, the liver, and the pancreas. The most commonly involved portions of the colon were the splenic flexure, the left transverse, and the upper part of the descending portion. In several instances there were injuries to two separate portions of the colon. The jejunum was the site of injury in the vast majority of the complicating lesions of the small intestine. Injury to the duodenum was a complication three times among the instances included in injuries to the small intestine.

The left adrenal gland was damaged in three instances. Injury to the gall bladder was a complication once. Major vascular injuries complicated the splenic injury in four instances. These involved the gastro-epiploic artery, the left renal vein, the celiac axis, and the thoracic aorta. The urinary bladder, the sigmoid colon and the rectum complicated the splenic injury in one instance each, but in all of these, the wounding agent made a separate entry.

ASSOCIATED INJURIES

Severe associated injuries occurred in 128, or 34.6% of the cases with damage to the spleen. Twenty of these had two or more associated injuries.

Injuries of the Spleen. (Assooiated Injuries, oontd)

The thoracic and intrapleural damage in thoraco-abdominal cases has not been included as associated injury except when such damage has resulted from separate missiles or agents.

The predominant associated lesions were severe soft tissue wounds, compound fractures, spinal cord injuries, major amputations, and wounds of the heart. (See Appendix, Table VII). The associated injuries were of such a degree that they often contributed considerably to the shock prior to surgery and to the postoperative oomplications that developed.

TREATMENT

Splenectomy was performed in 87.9% of all cases involving injuries to the spleen. (See Appendix, Table VIII). Among the 41, or 12.1% in which spleneotomy was not done, the vast majority were in stances where the splenio injury was classified as slight. In others, the procedures for caring for complicating lesions were of such a caliber that added splenectomy was deemed too much to be tolerated by the general condition of the patient. Splenectomy was not done in four instances where there was a severe splenic injury. Of these, three died on the table during surgery before the prooedure could be aocomplished. The fourth oase was an instance in which the splenio vein was found to be severed. Ligation of the bleeding vessel was the only measure taken.

In 70% of the cases where splenectomy was not done, the damage to the organ was so slight that no treatment was deemed necessary. Simple drainage of the site of injury was done in two instanoes, three were paoked four sutured, and two were sutured and packed. One was sutured with a muscle strip placed in the site of the splenic injury. Drainage of the splenio bed after splenectomy was recorded in nine cases.

We are of the opinion that splenectomy is the procedure of necessity except when the damage consists of a very slight fissure from which there is no active hemorrhage or evidence of more than slight previous hemorrhage. This procedure should be done at the earliest moment the patient has been rendered the best possible operative risk by adequate and proper resuscitative measures and preoperative preparation.

Suture of the spleen is a very unsatisfactory and inadequate measure to control active hemorrhage, to prevent subsequent hemorrhage, or to repair the damage to the viscus. Aside from the rather worthless consumption of time, there is danger of secondary hemorrhage. Such measures as suturing a musole strip into the damaged organ are to be condemned. This procedure does not assure complete hemostasis, either immediate or delayed. It is as time consuming as splenectomy. Packing the spleen is not advisable due to the inefficiency of the measure.

Injuries of the Spleen. (Treatment, contd)

Splenectomy should be done in any injury of the organ which warrants any treatment at all in the opinion of the surgeon.

"Abstention", as advised in American reports of World War I[1] is not advisable in the handling of splenic injuries under any circumstances.

OPERATIVE APPROACH

The operative approaches employed in the treatment of the splenic injuries in this series of cases were quite different from those used and advised in reports previously referred to in this discussion. The greatest departure was in the use of the transdiaphragmatic laparotomy. This departure was made possible by the constant availability of well trained anesthetists experienced in the use of endotracheal anesthesia, and excellent anesthetic apparatus.

In this series of injuries of the spleen occurring in thoraco-abdominal injuries, the transdiaphragmatic approach to the abdomen was used in 67% of the instances, The abdominal approach through any of the various incisions was used in 29% of the cases, and both approaches in seven instances. In those cases where the damage to the spleen occurred in abdominal injuries, an abdominal approach alone was used in every instance. The approach was not recorded in four instances of splenic injury. The left upper quadrant of the abdomen is accessible for intimate exploration when adequate and properly placed incisions are made in the thorax and the diaphragm. Splenectomy by this approach is an infinitely easier technical procedure than by any other. When it is obvious or questionable that there is damage to the viscera other than those in the left upper quadrant, an additional abdominal approach is well warranted. In the vast majority of left thoraco-abdominal injuries with damage to the spleen, we believe that the approach of choice is the transdiaphragmatic. In this group of cases in which the transdiaphragmatic approach was employed, the mortality rate was 19.8% as compared to 40% when an abdominal approach was used. (See Appendix, Table IX). This comparison does not take into consideration the fact that there was a greater frequency of severe complicating lesions contributing to a higher mortality in cases where an abdominal approach was used. However, there are certain left-sided thoraco-abdominal cases in which the abdominal visceral injuries can be managed more efficiently and with greater facility through the abdomen than by a transdiaphragmatic approach.

Considerable variance of opinion is possible and feasible in the choice and preference of various abdominal incisions. The left rectus and left paramedian were most commonly used in this series of cases. An extension of either of these to the left was used occasionally, but splenectomy as well as other surgery in the left upper quadrant and in other parts of the abdomen can usually be accomplished satisfactorily without the use of such an extension. The left subcostal or transverse

Injuries of the Spleen. (Operative Approach contd)

incisions are very satisfactory for splenectomy in some instances, however, the possibility of widespread visceral injuries may tend to condemn these incisions due to their somewhat limited scope of exploration. In addition, such incisions utilize the space best adapted for exteriorization of the colon when damage to it complicates the splenic injury.

Transdiaphragmatic laparotomy for handling splenic injuries occurring in purely abdominal cases is not generally advisable in war surgery. There is always the great possibility of the presence of complicating lesions that are not evident preoperatively, which cannot be properly explored and handled through the diaphragm. The question of contaminating an unharmed pleural cavity in cases where there are lesions of the stomach, small intestine, or colon complicating the splenic injury offers considerable argument against such an approach.

POSTOPERATIVE COMPLICATIONS

Postoperative complications were recorded in 21% of the total instances of splenic injury, whereas 41% had none. (See Appendix Table X). The records of 69 cases made no entry of any postoperative complications, but subsequent studies have revealed that a large proportion of these patients were evacuated without developing complications. Shock continuing after surgery has not been included as a complication.

The most common complications were anuria, occurring 12 times; wound infection, 11 times; and atelectasis nine times. Empyema and pneumonia each occurred five times; pulmonary embolism and left subphrenic abscess each three times; and disruption of the abdominal wound twice. Other complications that occurred in single instances were no different from those that may occur following any surgical procedure. There are no records of the occurrence of portal thrombosis, secondary hemorrhage from the spleen or splenic pedicle, or evidence of injury to the pancreas or stomach incurred accidentally during the operative procedure.

Eight of the nine instances of atelectasis occurred in thoracoabdominal cases. Colon injury was a complicating lesion in two of the three cases in which a left subphrenic abscess developed. Pulmonary embolism occurred in one case of uncomplicated splenic injury, one with associated compound fracture of one femur and traumatic amputation of the other leg, while a third was in a case complicated by severe injuries to the liver and stomach. All instances of anuria occurred in cases that showed severe shock before or during surgery, or in both, and in which large amounts of blood had been administered.

Injuries of the Spleen.

MORTALITY

Death occurred in 85 of the total number of cases of splenic injury, giving a mortality of 24.9%. This rate is considerably lower than the "estimated 40%" mortality in uncomplicated cases reported by Bailey[3], the 63% mortality reported in World War I[1]; the 33.3% by Jarvis[6]; 66.6% by Giblin[4]; and the 44.9% in Ogilvie's[5] combined series.* The mortality rate in uncomplicated splenic injuries in this series was 12%. That in thoraco-abdominal cases with splenic injury was 26.4%, whereas that in abdominal cases was 20.4%.

In that group of cases in which the transdiaphragmatic approach was used the mortality was 19.8%, as compared to 29.5% in all instances when an abdominal approach was used. Among the splenic injuries in thoraco-abdominal cases that were managed through an abdominal incision the mortality was 40%. (See Appendix, Table IX).

Death occurred within the first 24 hours in 43.5% of the fatal cases. Shock was the most frequent cause of death and was the primary cause in 53% of the cases ending fatally. Anuria occurred in 14% as the cause, and peritonitis in 7%. Other causes in order of their frequency were pulmonary embolism, pneumonia, and atelectasis. Lacerated coronary artery, gastric hemorrhage, and disruption of the diaphragmatic repair with atelectasis and herniation of the stomach and colon into the chest, each occurred once. The cause of death was not recorded in four cases, and was undetermined in three.

The mortality rate in cases in which splenectomy was performed was 24%, as compared to "practically 100% mortality following splenectomy" reported in World War I[1]. Twelve or 29.2% of the cases in which splenectomy was not done ended fatally; eight of these were in thoraco-abdominal cases. Three of these 12 cases died during surgery before splenectomy could be accomplished. The remaining nine either had severe complicating injuries, severe associated injuries, or both, or developed postoperative complications which led to death that could not be attributed solely to splenic injury.

*The rate quoted for this series covers only that period prior to the first evacuation toward the base hospitals. The reports used in this comparison do not state whether or not the mortality rate was computed from figures obtained after follow-up studies.

Injuries of the Spleen. (Mortality) contd.

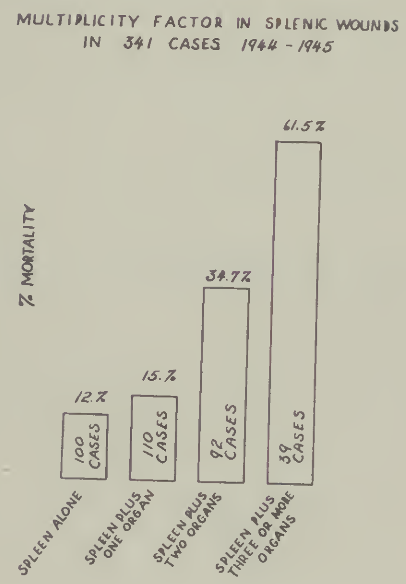

Figure 51 - Multiplicity Factor in Splenic Wounds

The mortality rate rose progressively and rapidly as the number of complicating visceral injuries increased, to reach 61.5% when three or more viscera were involved. Thirty-seven of the 85 fatal cases had severe associated injuries. No attempt has been made to evaluate the extent that these affected the outcome of the cases in which they occurred.

Injuries of the Spleen.

SUMMARY AND CONCLUSIONS

1. A review of 341 splenic injuries has been presented.

2. The incidence, operative approach, operative findings, treatment, postoperative complications and mortality have been described.

3. As compared with information in previous reports on splenic injuries, the incidence is greater and the mortality considerably lower in this series.

4. The transdiaphragmatic approach is recommended in a large proportion of instances of splenic injury in thoraco-abdominal wounds.

5. Splenectomy is the procedure advised when injury to the organ is such that any treatment is deemed necessary.

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APPENDIX

Splenic Injuries

TABLE I

Incidence of Splenic Injuries

Total Cases	Splenic Injuries	Incidence
3154	341	10.8%

TABLE II

Incidence of Injuries of the Spleen in Thoraco-Abdominal and Abdominal Wounds

Injuries to the Spleen In:	Number	Percentage of Total
Thoraco-abdominal cases	253	74.1%
Abdominal Cases	88	25.9%
TOTAL	341	10.8%

TABLE III

Incidence of Agents Producing Injuries of the Spleen

Wounding Agents

Shell Fragment	Rifle	Mine Fragment	Machine Gun	Bomb	Grenade Fragment	Non-Battle	Blast	No Record
202	75	25	14	7	2	4	3	9

TYPES OF INJURY AND OPERATIVE FINDINGS

Severe lacerating, penetrating, and perforating wounds and fractures showed multiple rents in the capsule radiating from the tract of the agent. Injury to the pedicle was the only damage to the organ in eight instances. Subcapular hematoma was described in three instances. Active hemorrhage from the spleen at the beginning of laparotomy was rare, but it usually recurred during the exploration in handling the damaged viscus.

TABLE IV

Types of Splenic Injury

Incidence of Types of Injuries of the Spleen

Slight Injury		Moderate Injury		Severe Injury	
No.	Percentage	No.	Percentage	No.	Percentage
32	9.38%	100	29.32%	209	61.29%

TABLE V

Incidence of Shock in Splenic Injuries

Clinical Evidence of Shock on Admission		None		Mild		Moderate		Severe		No Record	
		Total No.	Pct Died	Total No.	Pct Died	Total No.	Pct Died	Total No.	Pct Died	Total No.	Pct Died
In thoraco-abdominal injuries	Uncomplicated Splenic Injury	24	4.1	13	7.7	24	12.5	14	42.9	5	0
	Complicated Splenic Injury	35	5.7	17	17.7	51	21.5	61	62.3	9	22.2
In Abdominal Injury	Uncomplicated Splenic Injury	6	0	5	0	5	0	2	50.0	1	0
	Complicated Splenic Injury	13	0	8	25	15	26.6	26	42.3	6	0
TOTAL		78	3.8	43	13.9	95	19	103	54.3	21	9.5

Appendix, contd.

COMPLICATING VISCERAL INJURIES

The spleen was the sole abdominal viscus injured in 100, or 29.3% of the total cases in which it was involved. Eighty-two percent of this number occurred in thoraco-abdominal injuries, and 18% in abdominal injuries. Two hundred and forty-one, or 70.6% of the total instances of injury to the spleen had complicating abdominal visceral injuries. In addition to those listed in the following table, the duodenum was damaged in three instances, the left adrenal gland in three, and the gall bladder in one. Major vascular injury complicated four times, involving the gastro-epiploic artery, the left renal vein, the celiac axis, and the thoracic aorta.

TABLE VI

Incidence and Mortality of Visceral Injuries Complicating Splenic Injury.

Complicating Injuries

	Alone			With 1 Other Viscus			With 2 Other Viscera			With 3 Other Viscera			Total		
	Alive	Dead	Pct Mort.	Alive	Dead	Pct Mort.	Alive	Dead	Pct Mort.	Alive	Dead	Pct Mort.	Alive	Dead	Pct. Mort.
Spleen	88	12	12	93	17	15.4	60	32	34.7	15	24	61.5	256	85	24.9
Spleen & Stomach	33	8	19.5	23	16	41	10	8	44.4	1	10	90.9	67	42	38.5
Spleen and Colon	14	3	17.6	32	17	32.6	8	8	50	2	8	80	56	36	39.1
Spleen and Left Kidney	31	3	8.8	18	10	35.7	5	8	61.5	2	7	77.7	56	28	33.3
Spleen and Small Intestine	9	0	0	16	99	36	2	7	77.7	2	8	80	29	24	45.2
Spleen and Liver	4	2	33.3	19	7	31.8	8	6	35.7	0	4	100	31	19	38
Spleen and Pancreas	1	0	0	7	3	30	4	2	33.3	0	5	100	12	10	4 5.4

Appendix, contd.

ASSOCIATED INJURIES

The thoracic and intrapleural injuries of thoraco-abdominal cases have not been included as associated injuries unless these resulted from separate causes. Multiple associated injuries were present in 20 of these cases.

TABLE VII

Incidence of Severe Associated Injuries with Injuries of the Spleen

Associated Injuries

Soft Tissue		Compound Fracture		Cord Injuries		Amputations		Others	
Total	Death	Total	Deaths	Total	Deaths	Total	Deaths	Total	Deaths
53	14	36	10	13	6	6	1	20	6

Total. 128
Deaths. . . . 37

TREATMENT

The splenic bed was drained following splenectomy in nine cases. A muscle strip was sutured into the site of injury in one instance. The treatment was not recorded in one case which died on the table during surgery.

TABLE VIII

Treatment in Splenic Injuries With Mortality For Each Method

	Splenectomy		Others - No Splenectomy				
	Number	Deaths	Nothing	Drained	Packed	Sutured	Deaths
Thoraco-abdominal injury	224	60	21	1	1	6	7
Abdominal Injuries	75	13	8	2	1	1	5
TOTAL	299	24.4%	29	3	2	7	29.29%

Appendix, contd.

TABLE IX

Operative Approaches

Incidence of Approaches Employed in Handling Splenic Injuries. (The Approach was not Recorded in Four Cases)

Splenic Injuries In:	Transdiaphragmatic		Abdominal Approach		Both Approaches	
	No.	Mort.	No.	Mort.	No.	Mort.
Thoraco-abdominal injuries	171	19.8%	75	40%	7	28.6%
Abdominal Injuries	0	0	84	22.4%	0	0
TOTAL	171	19.8%	159	29.5%	7	28.6%

POSTOPERATIVE COMPLICATIONS

Peritonitis that was evident at the time of operation has not been included as a postoperative complication. Malaria complicated the postoperative course in three instances. Intestional obstruction, psychosis, pneumothorax and anaerobic infections occurred in two instances each. Massive hemoptysis due to a gastric hemorrhage, paroxysmal tachycardia, femoral phlebitis, pelvic abscess, jaundice, decubitus, heart failure, pulmonary edema, transfusion reaction and breakdown of the diaphragmatic repair occurred in one instance each.

TABLE X

Incidence of Postoperative Complications With Incidence of Death in Cases Having Complications. (This mortality rate is computed up to the time of the first evacuation toward the base hospital.)

Postoperative Complications

	Anuria and Oliguria	Atelec tasis	Wd. Infection	Empyema	Pneumonia	Pulmonary Embolism	Subphrenic Abscess	Wd. Disruption	Others	Total
Total Incidence	13	9	11	5	5	3	3	2	20	71
Deaths	12	0	2	1	2	3	2	0	3	25

Appendix, contd.

TABLE XI

Incidence of Mortality in Injuries of the Spleen

	Number Cases	Number Deaths	Percentage Mortality
Thoraco-abdominal cases	253	67	26.4%
Abdominal cases	88	18	20.4%
TOTAL	341	85	24.9%

PRIMARY CAUSES OF DEATH

Causes included under "others" having a single incidence were: vago-vagal reflex following bronchoscopy, transfusion reaction, spinal meningitis, lacerated coronary artery, massive empyema, bilateral hemothorax, gastric hemorrhage, and disruption of the diaphragmatic repair with atelectasis and herniation of the stomach and colon into the chest.

TABLE XII

Incidence of Primary Causes of Death in Splenic Injuries

Shock	Anuria	Peritonitis.	Pulmonary Embolism	Pneumonia	Atelectasis	Others	Undetermined	Not recorded	Total
44	12	6	3	2	2	9	3	4	85

Appendix, contd.

TABLE XIII

Incidence of Primary Causes of Death with Time of Death in Cases Having Splenectomy

	Died on Table	Up to 12 Hrs	From 12 to 24 Hrs	1st Po. Day	2nd and 3rd Po. day	4th thru 7th Po. Days	After 7th Po. Day	Total
Shock	7	13	8	6	4	0	0	38
Anuria	0	0	0	0	6	5	1	12
Periton-itis	0	0	1	0	1	2	1	5
Pulmonary Embolism	0	0	0	0	2	1	0	3
Pneumonia	0	0	0	0	0	1	0	1
Atelectasis	0	0	0	1	0	0	0	1
Others	3	1	0	0	1	2	0	7
Not Recorded	0	0	0	0	3	0	0	3
Undeter-mined	0	0	0	0	1	1	0	2
TOTAL	10	14	9	7	18	12	2	72

Appendix, contd.

TABLE XIV

Incidence of Primary Causes of Death with Time of Death in Cases Having no Splenectomy

	Died on Table	Up to 12 Hrs	From 12 to 14 Hrs	1st Po. Day	2nd and 3rd Po. Days	4th thru 7th Po. Days.	After 7th Po. Day	Total
Shock	3	0	1	1	1	0	0	6
Peritonitis	0	0	0	0	0	1	0	1
Anuria	0	0	0	0	0	0	0	0
Pulmonary Embolism	0	0	0	0	0	0	0	0
Pneumonia	0	0	0	0	0	0	1	1
Atelectasis	0	0	0	0	1	0	0	1
Others	0	0	0	0	0	2	0	2
Undetermined	0	0	0	0	0	1	0	1
TOTAL	3	0	1	1	2	4	1	12

Eight of these 12 deaths in cases that had no splenectomy occurred in thoraco-abdominal cases. Causes listed as "other" in the table above were transected spinal cord with meningitis, and gastric hemorrhage.

INJURIES OF THE PANCREAS

Pancreatic injuries were uncommonly encountered in the series of cases included in this report. This coincides with the experiences expressed in previous reports on war wounds. Involvement of this viscus was seen less frequently than that of any other major abdominal organ.

TABLE I

Incidence and Mortality of Uncomplicated and Complicated Injuries of the Pancreas

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. Cases	Incidence in 3154 cases	Mortality Rate	No. Cases	Incidence of cases	Mortality	No. Cases	Incidence of cases	Mortality
62	1.9%	56.5%	1	1.6%	100%	61	98.4%	55.7%

INCIDENCE

Pancreatic injuries were present in only sixty-two instances among the 3154 abdominal and thoraco-abdominal wounds covered in this report, an incidence of 1.9%. Available previous reports included only slight mention of such injuries. Damage to the pancreas was reported in only 0.2% of all the abdominal injuries sustained by the American Expeditionary Forces in World War I.[1] Jolly reported four instances of such injuries in 970 cases in the Spanish Civil War.[2]

Severe complicating lesions leading to death prior to admission to a hospital probably accounted for such a low incidence of pancreatic injuries. The presence of such complicating lesions and the high mortality in these cases that reached a hospital would tend to substantiate this. In addition, the possibility of the failure to discover the pancreatic lesion would also contribute to the low incidence. The pancreatic injuries in three cases of this series were not found until autopsy.

CAUSATIVE AGENTS

Agents causing injuries of the pancreas were of the same type and essentially the same frequency as those in all abdominal wounds. All instances occurred in battle casualties. (See Table I, Appendix).

TYPES OF INJURIES OF THE PANCREAS

Lacerations and perforations of the pancreas were by far the most common types of injuries. Penetrating wounds of the viscus were present

Injuries of the Pancreas. (Types of Injuries of the Pancreas contd)

in five instnces, and the organ was transected in three cases. The head of the pancreas was involved in 22.6% of the instances, the tail in 38.8% and the body in 22.6%. The pancreatic duct was damaged along with the head of the viscus on two occasions. The location of the injury was not recorded in ten, or 16.1% of the instances of involvement.

TABLE II

Frequency of Sites of the Pancreatic Injury

Site of Injury				
Head	Tail	Body	Duct	Not Recorded
14	24	14	2*	10

Peritonitis due to the pancreatic secretions was noted at the time of the operation only once.

CLINICAL FINDINGS

Shock was present in all cases. No particular findings were noted which caused suspicion of damage to the pancreas. In this series, the pancreatic injuries were in thoraco-abdominal wounds in 51.6% of the instances, and 48.4% were in abdominal wounds. (See Table II, Appendix).

COMPLICATING INJURIES

The pancreatic injuries were complicated by other visceral injuries in all instances except one. The damaged organs that complicated the injuries of the pancreas were, in the order of their frequency, the stomach, liver, spleen, kidney, colon, duodenum, and small intestine. Damage to two or more viscera complicated the pancreatic injury in 74.2% of the instances. (See Table III, Appendix). Vascular injuries complicated the lesions of the pancreas in thirteen instances, an incidence of 20.9%. Visceral damage was present in all the cases in which vascular injuries complicated the pancreatic injuries (See Table IV, Appendix).

*Both of these instances occurred along with injuries of the head of the organ.

Injuries of the Pancreas. (Complicating Injuries contd)

TABLE III

Incidence and Mortality in Complicating Visceral Lesions in Pancreatic Injuries

	Multiplicity Factor in Complicating Visceral Lesions					
	Pancreas Alone	Pancreas plus 1 organ	Pancreas plus 2 organs	Pancreas plus 3 organs	Pancreas plus 4 organs	Total
Total	1	15	22	15	9	62
Percentage Mortality	100%	33.3%	50%	60%	100%	56.5%

ASSOCIATED INJURIES

Severe associated injuries occurred in 16 instances, or 25.8% of the cases with lesions of the pancreas. Compound fractures and severe soft tissue wounds were each associated in seven instances, and injury to the spinal cord twice. (See Table V, Appendix).

OPERATIVE APPROACH

One of the various abdominal incisions was employed in handling the injury to the pancreas and its complicating lesions in 48, or 77.4% of the cases. A transdiaphragmatic approach was used in 12 or 19.3% of the 32 instances in which the pancreatic injuries occurred in the thoraco-abdominal wounds. The approach was not recorded in two or 3.2% of the cases. (Table VI, Appendix).

Due to the secondary role played by the pancreatic injuries in these cases, the approach was chosen which afforded the greatest facility in handling the complicating lesions.

TREATMENT

In this series of pancreatic lesions, drainage of the site of the injury was the sole treatment in 24, or 38.7% of the cases. The injury was sutured and drained in 11, or 17.7% of the cases, and packed and drained once. Suture alone was done in six, or 9.6% of the pancreatic injuries, and the site of damage was packed alone in four, or 6.4%, of the instances. Partial pancreatectomy was performed in three cases, and drainage was afforded in two of these. In the two patients having an

injury to the pancreatic duct, an attempt at repair was made in one, and the duct was ligated in the other.

No treatment was done to the lesion of the pancreas in 13, or 20.9%, of the cases. Of these, four died during the operation, and three of the injuries of the pancreas were not discovered. No remarks were recorded concerning the six remaining cases in which nothing was done to the damaged pancreas. (See Table VII, Appendix).

Drains were recorded as being used in pancreatic injuries in 61.3% of the cases for the purpose of affording the escape of pancreatic secretions and preventing the development of pseudo-cysts. Packing and sutures were used to control hemorrhage.

POSTOPERATIVE COMPLICATIONS

Postoperative complications occurred in 13, or 20.9% of the cases having pancreatic injuries. Anuria occurred in five cases. Digestive peritonitis was noted twice in this series, one instance of which was identified at the operation, and the other at post-mortem examination. Other postoperative complications which occurred once each were femoral phlebitis, biliary fistula from an overlooked injury to the common duct, pulmonary edema, pneumonia and empyema, jaundice, and gastric hemorrhage. (See Table VIII, Appendix).

Shock continuing after the operation has not been included as a postoperative complication.

MORTALITY

Death occurred in 35 instances in this series of pancreatic injuries, a mortality rate of 56.5%*. Six, or 17.1%, of the total deaths occurred on the table during, or immediately following, the operation and an additional 13, or 37.1%, died within the first twenty four hours after surgery. (See Table IX, Appendix).

Shock or hemorrhage, or both, were the primary causes of death in 21, or 60% of the instances. Anuria was the cause in five, or 14.3% of the deaths, and peritonitis in three. Others which were the cause in single instances were pancreatitis, pulmonary edema of undetermined origin, atelectasis, vago-vagal reflex following bronchoscopy, gastric hemorrhage, and pneumonia. (See Table X, Appendix).

The single instance of uncomplicated pancreatic injury ended fatally on the eighth postoperative day due to pneumonia and empyema. Death occurred in ten, or 77% of the 13 cases in which no treatment to the injured pancreas was done. Four of these died during surgery, one was

*The corrected mortality rate for unrecorded deaths occurring in first priority surgical hospitals shows approximately 2% increase in all abdominal wounds.

Injuries of the Pancreas. (Mortality contd)

due to pancreatitis, one due to hemorrhage and shock, and one due to hemorrhage from a lesion of a mediastinal vessel. Death was due to anuria in one of the three cases in which the pancreatic lesion was not found until autopsy. Bile peritonitis arising from an overlooked injury of the common bile duct caused death in another, and peritonitis due to an unrecognized lesion of the duodenum was the cause in the third. All three had severe visceral lesions or vascular injuries along with the pancreatic damage. Eleven, or 84.6% of the cases which had complicating vascular lesions died.

The mortality rate in complicated cases increased rapidly with each additional injury that complicated the pancreatic lesion to reach 100% when four or more organs were involved. See Table III, Appendix).

SUMMARY

1. A review of 62 pancreatic injuries has been presented.

2. The incidence of injury is lower, and the mortality higher than that of any other major abdominal viscus.

3. Drainage of the site of the pancreatic injury was recorded as the principal measure of treatment in 61.3% of the instances.

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Injuries of the Pancreas, Appendix.

TABLE I

Wounding Agents

Incidence of Wounding Agents in Injuries of the Pancreas

Agents	Shell Fragment	Rifle	Mine Fragment	Bomb	Machine Gun	Not Recorded
Times	35	20	2	2	1	2

TABLE II

Distribution of Pancreatic Injuries

Distribution and Mortality of Injuries of the Pancreas in Abdominal and Thoraco-Abdominal Wounds

Abdominal Wounds			Thoraco-Abdominal Wounds		
No. Pancreatic Injuries	Percentage of Pancreatic Injury	Mortality	No. Pancreatic Injury	Percentage of Pancretic Injury	Mortality
30	48.4%	63.3%	32	51.6%	50%

Injuries of the Pancreas. (Appendix contd)

TABLE III

Complicating Injuries

Frequency and Mortality of Complicating Lesions in Injuries of the Pancreas

Organs Involved	Alone No.	Alone Mort.	With Other Organs Involved	Total	Mortality
Pancreas and Stomach	4	25%	33	37	59.4%
Pancreas and Liver	5	40%	20	25	60.0%
Pancreas and Spleen	2	-	20	22	50.0%
Pancreas and Kidney	1	-	19	20	80.0%
Pancreas and Colon	3	66.6%	14	17	70.6%
Pancreas and Duodenum	-	-	11	11	81.8%
Pancreas and Intra-abdominal vascular injury	-	-	13	13	84.6%
Pancreas and Small Intestine	-	-	8	8	87.5%

TABLE IV

Complicating Vascular Lesions

Frequency of Complicating Intra-Abdominal Vascular Lesions in Injuries of the Pancreas

Vessel Involved	No. of Cases	Mortality
Inferior Vena Cava	5	100%
Splenic Pedicle	4	75%
Renal Pedicle	2	50%
Duodenal and Pancreatic Vessels	1	100%
Lumbar Artery	1	100%
TOTAL	13	84.6%

Injuries of the Pancreas. (Appendix contd)

TABLE V

Associated Injuries

Frequency of Severe Associated Injuries in Pancreatic Injuries
(Multiple Associated Injuries were Present in some Cases)

Type	Number	Deaths
Compound Fractures	7	5
Soft Tissue Wounds	7	1
Cord Injuries	2	2
Total Associated Injury	16	8
None	46	26

TABLE VI

Incidence of Approaches Used In Pancreatic Injuries Occurring in Abdominal and Thoraco-Abdominal Wounds.
(The Approach was not Recorded in one Thoraco-Abdominal and One Abdominal Case)

Pancreatic Injuries in:	Approaches: Abdominal Approach: Number	Abdominal Approach: Percentage of cases	Transdiaphragmatic Approach: Number	Transdiaphragmatic Approach: Percentage of cases
Thoraco-Abdominal Cases	20	62%	12	37.5%
Abdominal Cases	28	100%	0	0
TOTAL	48	77.4%	12	19.3%

Injuries of the Pancreas. (Appendix contd)

TABLE VII

Methods of Treatment of Injuries of the Pancreas with Deaths Occurring in Each

Treatment

Treatment	Number of Cases	Deaths
Drained Only	24	12
Drained and Sutured	11	6
Sutured Only	6	4
Packed Only	4	3
Partial Pancreatectomy	3	0
Drained and Packed	1	0
No Treatment	13	10*

*The pancreatic injury was found at autopsy in three of these cases, and death occurred on the table during surgery in four others.

TABLE VIII

Incidence of Postoperative Complications in Pancreatic Injury With Mortality Rate of Each

Postoperative Complications

	Anuria	Atelectasis	Others*
Number	5	2	6
Mortality	100%	-	83.3%

*One case had femoral phlebitis as a postoperative complication and lived. The remainder ended, fatally, and included a biliary fistula from an overlooked injury to the common bile duct, pulmonary edema of undetermined origin, empyema, jaundice, and a gastric hemorrhage.

Injuries of the Pancreas. (Appendix contd)

TABLE IX

Relation of Time of Death to the Operation in Pancreatic Injuries

Time of Death	Died on Table	Postoperative: First 12 hrs.	From 12 hrs to 24 hrs.	1st P.O.	2nd P.O.	3rd & 4th P.O.	5th thru 7th P.O.	After One Week
Number	6	9	4	2	3	1	7	3
Percentage of Total Deaths	17.1%	25.7%	11.4%	5.7%	8.6%	2.8%	20%	8.6%

TABLE X

Incidence of Primary Causes of Death in Pancreatic Injuries

Primary Cause	Shock and Hemorrhage	Anuria	Peritonitis	Others*
Number	21	5	3	6
Percentage of Total Deaths	60%	14.3%	8.6%	17.1%

*Included in one instance each, are pulmonary edema, pancreatitis, atelectasis, vago-vagal reflex, a gastric hemorrhage, and pneumonia.

A STUDY OF 427 WOUNDS TO THE KIDNEY IN 3154 ABDOMINAL AND THORACO-ABDOMINAL WAR INJURIES

Wounds to the kidney occurred in 6.3% of all abdominal injuries reported from the records of the Office of the Surgeon General of The United States during World War I[1]. Jolly[2] reported 19 instances of renal involvement in 238 cases seen in the Spanish Civil War, or 8.3%.

A study of 3154 wounds of the abdomen, operated upon by teams of the 2nd Auxiliary Surgical Group in forward surgical hospitals, revealed 427 wounds to the kidney, an incidence of 13.4%. Fifty-six of these wounds (13.1%) were limited to the kidney. All others were complicated with wounds to other organs. (Appendix, Table I and II).

There were 284 admissions (Appendix,Table III) with wounds of the kidney that were caused by fragmentation missiles. The number included wounds from all types of grenades, artillery shells, land mines, booby-traps, and bombs. Gunshot wounds accounted for 115 (26.9%) of the wounds to the kidney, somewhat less than one third of the wounding agents. There was no record of the wounding missile in 28 cases.

SPECIFIC ANATOMY FROM THE SURGICAL VIEWPOINT

The anatomy of the kidney is such that it has certain advantages and disadvantages with respect to its vulnerability to injury in time of war. It is particularly protected within the body by adipose tissue, muscle, bone, and visceral structures of the abdomen and chest. On the other hand, it bears such close anatomic relationship (Figure 52 and 53) with other structures that wounding of the kidney was complicated over 86% of the time with wounds to other organs by the same missile.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Specific Anatomy from the Surgical Viewpoint, Cont'd).

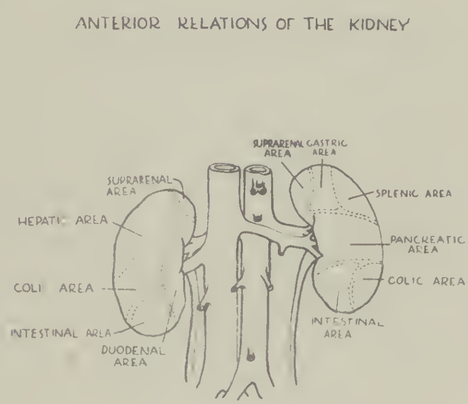

Figure 52 - Anterior Relations of the Kidney.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Specific Anatomy from the Surgical Viewpoint, Cont'd).

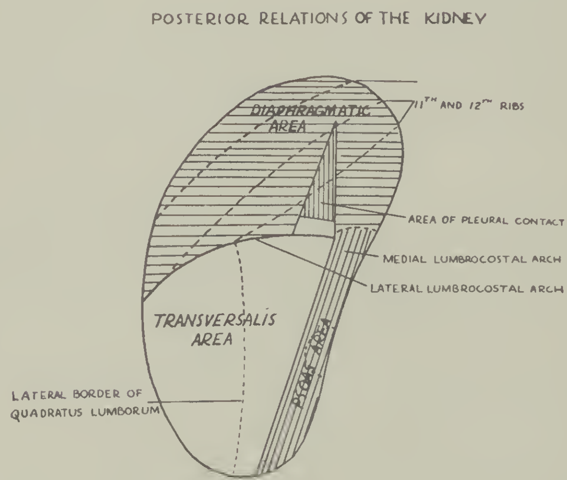

Figure 53 - Posterior Relations of the Kidney

The peri-renal adipose tissue may cushion the blow to the kidney from the missile, for it was noted in certain instances, that extensive fragmentation of the liver or spleen was accompanied by perforation or segmental destruction of the kidney.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Specific Anatomy from the Surgical Viewpoint, Cont'd).

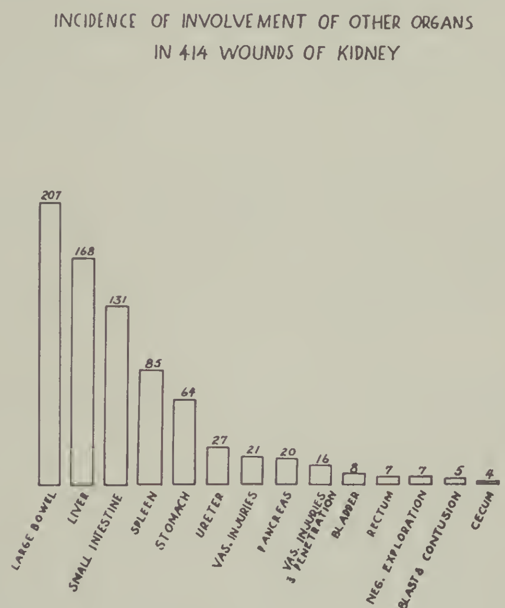

Figure 54 - Incidence of Involvement of Other Organs in 414 Wounds of Kidney*

*Thirteen additional cases of renal wounding were reported after the chart had been made. The complicating organs involved make no practical alteration in the chart.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Specific Anatomy from the Surgical Viewpoint, Cont'd).

Anomalies

The possibility of performing nephrectomy upon a patient with agenesis of the opposite side was not disregarded despite the fact that cystoscopy or urography were not feasible in forward areas. Every effort was made to distinguish renal shadow by roentgen examination on the uninjured side prior to surgery. Examination of the necropsy records does not reveal any instance of agenesis, fused or horseshoe kidney.

Gross Pathology of Renal Wounds

Renal wounds may be divided for convenience of discussion into two classes:

1. Those involving the hilum of the kidney.
2. Those involving the parenchyma.

Probably most of the wounded who had incurred injury to the major blood vessels of the abdomen, including the renal artery and vein, did not survive to reach surgery. There were sixteen cases in which the renal vessels had been lacerated or severed. Nine died, six were evacuated in good condition within 10 days following surgery. One had no record of disposition. Nephrectomy was performed in each instance. The known mortality was 60%. Four patients died within 20 hours following surgery from continued severe shock, one lived 72 hours in severe shock, while another died on the fifth day postoperative from peritonitis. In two instances damage to the inferior vena cava complicated the wound to the hilar vessels. One of these involved complete transection of the cava and the patient died during the operation The second required nephrectomy, but involved laceration to the vena cava which could not be sutured. The vena cava was ligated and the patient survived with apparently normal urinary volume. He was evacuated on the ninth day following surgery.

There was but one wound to the pelvis recorded in which the vessels were not damaged. Repair of the small laceration was done with one interrupted suture followed by uneventful recovery.

Parenchymal wounds varied from neatly drilled holes to complete maceration. There did not appear to be any relation between the type of missile and the character of the wound. The size of the missile and its velocity were, however, directly responsible for the degree of destruction. There was practically always a certain amount of hematoma

in the perirenal area, but active bleeding from the renal wound at time of surgery was not constant. The wound was usually covered with an irregular clot which was rather firmly adherent to the wound edges. An attempt to dislodge the clot usually resulted in renewed bleeding from the wound surface. Even in the event of destruction of large sections of one or the other of the poles there was but little active bleeding found at surgery.

Although there was frequently communication through the wound into the pelvis of the kidney, attempts to identify urine in the wound or about the kidney met with little success.

Cortical hemorrhage frequently separated the tunica fibrosa to considerable extent. This resulted in varying degrees of disturbance of the anatomical relation of the capsule to the cortex. During mobilization, the finger of the operator often perforated the distended capsule and actually a subcapsular dissection was done.

CLINICAL PICTURE

Hematuria and location of the wound were the primary indications of damage to renal structures. The presence of gross or microscopic blood in voided or catheterized urine specimens was the greatest single finding in the diagnosis of renal trauma.

The uncomplicated renal wound was most often caused by a missile traveling at low velocity. In this case, the fragment was found in the kidney or adjacent to it. At other times, the angle of penetration was such that the kidney alone was wounded. Wounding of the renal parenchyma alone did not always elicit particularly severe general reaction, and shock was commonly absent or of mild nature.

The complicated wound presented a much more extensive and varied problem. The signs of wounding to the complicating structures often overshadowed the renal trauma. It was this group of patients that was most commonly seen in forward surgical installations, and comprised the greatest share of kidney injuries.

Size of entrance or exit wound is no indication of the extent of wounding to the kidney.

It was sometimes possible by careful inspection to detect disparity between the flanks in kidney wounds, but this was almost entirely dependent upon the amount of tissue destruction and hematoma. Bleeding from wounds of the flank and loin were in no manner conclusive of

hilar damage for the renal parenchyma can bleed vigorously, and intraperitoneal blood can also escape from a flank wound.

We know of no case of wounding to the kidney in which pain was referred in the classic manner along the course of the ureter to the groin or scrotum. Commonly, pain was referred to the abdomen.

DIAGNOSIS

Catheterization was almost routinely necessary to recover urine specimens. The bladder must be completely drained in order to rule out hematuria. It was not unusual to note the first portion to be clear, but the last to become grossly colored. This was especially true of patients with a long time interval since wounding.

Close inspection of wounds was especially pertinent to the determination of structures involved. Considerable helpful information can be gained if the patient can describe his position at the time of wounding, or the direction from which the missile came. This was especially true in penetrating wounds.

There was usually tenderness and guarding of the muscles of the flank to palpation to the extent that deep palpation was difficult. Diagnostic acumen was sorely tried in the complicated wound because of the predominance of intra-abdominal objective signs and symptoms. Frequently, the degree of shock was so severe that until resuscitation therapy had progressed sufficiently, physical findings by palpation were totally unreliable. In addition, hemoperitoneum or peritoneal contamination from a perforated hollow viscus caused such muscular guarding of the abdomen that examination was only possible with great care and urging of cooperation from the patient. On a very few occasions, retroperitoneal hematoma was palpable through the flank and abdomen.

Thoraco-abdominal wounds comprised 162 of 427 wounds, or 43.6% of all the wounds involving the kidney. (Appendix, Table IV).

The usual area of penetration was posteriorly and posterolaterally from the chest into the abdomen, and frequently involved the costophrenic angle. On the left side of the abdomen, when there was wounding to the thorax associated, the spleen and kidney were both involved 56 times (69.1%). Without thoracic involvement, the spleen and kidney were associated 25 times (30.9%).

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries

RADIOGRAPHY

In forward surgical units, roentgenology was limited to flat plate exposures of film, and fluoroscopy. Stereoscopy and similar refinements were not available. A common error encountered was the limitation of exposure to the abdomen when the wound was in that area. A mild hemothorax was at times missed in physical examination that would have been detected if the lower chest had been included in the projection, or if separate chest film had been made. Retrograde pyelography was not done. Cystoscopy is attended with some degree of shock, and this in addition to shock already existent, was felt to further jeopardize the life of the patient. Intravenous urography was not practised.

Resuscitation therapy was well standardized in forward areas and differed in wounds to the kidney. in no manner from that for any other wound.

OPERATIVE TREATMENT

The conservative treatment of renal trauma was carried into operative procedure. Every attempt was made to avoid nephrectomy if at all possible. Damage to the renal vessels, extensive destruction of the parenchyma or widespread fracturing with destruction of the blood supply to segments required nephrectomy.

There were 120 nephrectomies performed (Appendix, Table IV) of which there were 16 for reason of wounding to the renal artery and vein. The remainder were done because of extensive parenchymal destruction. One of the three kidney wounds overlooked died because of continued bleeding from laceration to the renal vein.

Seventeen nephrectomies (Appendix Table V) were done in 56 uncomplicated cases with a mortality of four (23.5%). The complicated renal wounds required nephrectomy 103 times. Death occurred 49 times (44.1%). Shock was the most commonly recorded cause of death.

Of the four deaths in uncomplicated renal injury, there was one death from anuria, one died of shock 20 minutes postoperatively, a third case died on the seventh postoperative day of an anaphylactic shock following 100 cc of Alsever's solution intravenously. The fourth case died on the fourth postoperative day of ascending myelitis from an associated cord injury.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Operative Treatment, cont'd).

Hemorrhage from the renal parenchyma was not always found at time of operation. When it did occur, however, moist packs to the kidney frequently controlled the bleeding.

Resection and repair was done on seven kidneys with one death attributed to peritonitis. The procedure was not popular among the surgeons of the Group, and the autopsy finding in the one case may be significant as to the reason resection or suture was not considered favorably. Notation was made that "During the three day interval between surgery and death, the sutures had become buried in the swollen renal parenchyma, while the areas included were dark, and engorged with blood on cut section".

Drainage was considered a routine procedure in every operation where wounding occurred. Two hundred eighty-five of the 427 cases were treated by drainage alone. There were but eight instances in which there was no drainage established.

The abdominal transperitoneal approach (Appendix, Table VI) was the most commonly employed incision (60.6%) because of the necessity for exposure of the abdominal viscera. The possibility of retroperitoneal contamination was admitted, but all too frequently this had already come about as a result of the wound. A combination of abdominal and loin incision was not used, chiefly because of the time element involved.

Wounding to the thorax and kidney occurred in 147 instances or 34.4% of 427 renal wounds. (Appendix Table VII).

An analysis of the figures shows that where the wound of the thorax was below the eighth interspace, thoracotomy was done in 64 instances and trans-diaphragmatic entrance made into the abdomen and retro-peritoneal area. We believe this approach to the kidney is convenient and where indicated, is attended by good results.

Separate thoracic and abdominal incisions were used in 40 cases, abdominal incision alone in 39, and flank incision three times. One case died of shock after surgery of an overlooked laceration to the left renal vein.

Flank or loin incision (12.4%) was the preferable approach in wounding that was limited to the upper quadrant. Exposure was excellent, the incision was capable of extension antro-medially for celiotomy and procedures necessary to the abdominal viscera.

The flank incision healed by primary intention in practically every instance. However, it is the most favorable area for exteriorization of the colon. This is the main objection to the incision.

Suture Materiel

The routine supply of suture material was quite adequate in all instances with the exception of that suitable for segmental resections and repair of fractures of the parenchyma. The inclusion of ribbon suture in the supply to forward areas would have been an incentive to an even greater conservative attitude and fewer nephrectomies.

Drainage Materiel

Soft rubber materiel of the Penrose type. with or without wick, afforded adequate drainage and was easily removable.

Incisions for drainage

Debrided missile tracts in the flank or loin were employed as drainage areas for renal wounds. The fact that they were to be used as such in no manner precluded thorough debridement.

Some criticism can be directed at the inadequacy of some stab wounds. Muscular relaxation during anesthesia was deceptive. It was obvious that muscle and fascia had to be widely divided to insure patency after muscle tonus had returned. We believe there is little danger of herniation.

Packing

Packing of the kidney and renal area with gauze was used in but three instances. There was active renal parenchymal bleeding in but one case.

The opinion of surgeons of the Group is that gauze packing, as it is used to control bleeding, could preferably be avoided as far as surgery of war wounds is concerned. Because firm pressure is necessary to accomplish hemostasis the gauze is usually packed firmly from renal fascia to the skin level. The immediate consequence is lack of drainage to an area already potentially, if not actually, infected. The adherent and irritating nature of the materiel may cause bleeding upon its removal.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries.

COMPLICATIONS

The common complications of renal trauma are:

1. Sepsis
2. Secondary hemorrhage
3. Urinary fistula

Sepsis was most commonly associated with perforation of the retroperitoneal colon. Thorough wound debridement with removal of tissue debris, clothing, free blood, and metallic foreign bodies was necessary, in addition to adequate drainage for the control of infection.

There were no recorded instances of secondary hemorrhage in the series.

The formation of urinary fistula occurred following parenchymal wounding that involved the pelvis. Pocketing of urine due to inadequate drainage was not common, but when it did occur, there was febrile reaction and the general condition failed to improve until adequate drainage was established. It was not uncommon to note urine on dressings following drainage for renal wounding, but it generally ceased spontaneously after two to three days. Nephrostomy was not done in any case in the series.

POSTOPERATIVE CARE

Dressings covering a considerable wound in the flank through which drainage of the renal fossa has been established, generally require several changes of dressings daily. A convenient method was to cover the wound with a few sterile folded gauze sponges reinforced by one or two abdominal pads. The dressing was held in place by a large bath towel encircling the abdomen and secured anteriorly with safety pins. Excoriation of the skin by adhesive tape was therefore avoided and the dressings are more easily changed.

Drainage material was left in place as long as there was any significant soiling of the dressings, which was usually seven to 10 days.

Adequate fluid intake was necessary, and ranged from 2000 to 3000 c.c. daily by mouth or infusion.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries.

MORTALITY

There were 155 deaths among 427 incidents of wounding involving the kidney, a mortality of 36.3%. Of the 56 wounds to the kidney alone, there were nine deaths (16.7%). The mortality increased in direct proportion to the multiplicity of complicating organs wounded at the same time (Appendix, Table VIII). The incidence of multiple wounding decreased after wounding to the kidney plus one other organ, which constituted the greatest single group. One hundred and twenty (81%) of the deaths from wounds involving the kidney occurred within 72 hours following surgery (Appendix, Table IX). The greater part of these patients had suffered mortal wounds. Their response to shock therapy and surgery was very minimal. Twelve patients died on the operating table. In addition to severe primary and secondary shock, there were other contributory factors such as pulmonary edema (1), far advanced generalized peritonitis (2), anuria (2), ascending myelitis (1).

There were 28 deaths (18.6%) occurring after the second post-operative day. The severity of wounds, shock from hemorrhage, peritoneal contamination, and pulmonary association are the particular reasons for early deaths.

SUMMARY

1. A study was made of 427 wounds to the kidney found among 3154 abdominal and thoraco-abdominal wounds.

2. There were 56 wounds involving the kidney alone of which nine died, a mortality of 16%.

3. Three hundred and seventy-one (86.8%) of the renal wounds were complicated by wounds to other organs. One hundred and sixty-two of these wounds involved the thorax.

4. Renal vascular injuries accounted for sixteen wounds. Nine of these cases died.

5. The principle of treatment was conservatism and drainage wherever possible.

6. The use of gauze packing to the kidney was not favored.

7. Nephrectomy was performed 120 times, or in 28.1% of all the wounds. The mortality was 44.1%.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Summary, cont'd).

8. An abdominal incision was employed 255 times (60.6%), thoracic approach 107 (25.2%), and flank or loin incision 52 (12.1%). There was no record of the incision in seven cases.

9. Thoracotomy was the most frequently used incision in dealing with renal wounds involving the thorax. The mortality was lower (23.4%) than with any of the other incisions employed.

10. There were 155 deaths (36.3%) in 427 wounds. Eighty-one per cent (120) of the deaths occurred before the end of the second post-operative day.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries.

APPENDIX

TABLE I

Incidence of Renal Involvement in 3154 Cases

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. Cases	Incidence in 3154 Cases	Mortality Rate	No. Cases	Incidence	Mortality	No. Cases	Incidence	Mortality
427	13.4%	36.3%	56	13.1%	9	371	86.8%	146

TABLE II

Comparative Incidence of Previous Studies

Authority	Total Abdominal Wounds	Total Renal Wounds	Per cent
Young[3]	2385	129	5.4
Wallace[4]	965	73	7.5
Jolly[2]	238	19	8.8
Present Series	3154	427	13.4

TABLE III

Incidence of Types of Missiles
Wounding the Kidney in 427 Cases

Fragmentation*	Gunshot Wounds	Others and Not recorded
284	115	28
66.5%	26.9%	6.5%

*Includes aèrial bombs, artillery and mortar shells, grenades of all types, and land mines.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Appendix, cont'd).

TABLE IV

Surgical Procedures in Treatment of 427 Renal Wounds

Surgical Procedure	Number	Per cent
Drained Only	285	66.7
Nephrectomy	120	28.1
No Treatment	8	1.8
Resection or Suture	7	1.6
Packed	3	.8
Overlooked	3	.8
Capsulotomy	1	.2
TOTAL	427	100.0

TABLE V

Nephrectomy in 427 Cases

GROSS TOTALS			UNCOMPLICATED CASES			COMPLICATED CASES		
No. Cases	Incidence in 427 Cases	Mortality Rate	No. Cases	Incidence	Mortality Rate	No. Cases	Incidence	Mortality Rate
427	120	44.1%	56	17	23.5%	371	103	44.1%

TABLE VI

Anatomic Distribution of Incisions in 427 Wounds involving the Kidney

	*Abdominal	Thoracic	Flank	No record
Kidney	255	107	52	7
Kidney and Ureter	4	1	1	
Per cent of Total	60.6	25.2	12.4	1.6

* Includes midline muscle splitting or retracting and anterior subcostal.

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Appendix, cont'd).

TABLE VII

Incidence of Thoraco-Abdominal Wounds
Involving the Kidney and Incisions Employed

Total	Thora-cotomy	Thoraco and Abdominal	Abdominal	Flank	Overlooked
Number 147	64	40	39	3	1
Mortality 67	15	20	30	1	1
Per Cent Mortality 45.5	23.4	50.0	76.9	33.3	100.

TABLE VIII

Relative Increase in Mortality With
Additional Complicating Wounds to Other Organs

Number Involved	Kidney Only	+ 1	+ 2	+3	+4
Times Involved	56	172	105	47	24
Number of Deaths	9	41	38	30	19
Per Cent Mortality	16.0	23.8	36.1	63.8	79.1

Eight cases involving five and six organs complicating were deleted because their number was too small to be significant. Four cases also deleted because of unreliable recording.

TABLE IX

371 Complicated Renal Wounds
Relative Frequency of Death within 72 hours of Operation

	No. of Deaths	Percent of all Deaths
Death Within 72 Hours Postoperatively	120	81.6
Death After 72 Hours Postoperatively	29	18.4
TOTAL	149	100.0

A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-Abdominal War Injuries (Appendix, cont'd).

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PERTINENT DATA IN 27 WOUNDS TO THE URETER AMONG

3154 ABDOMINAL CASES

Four wounds to the ureter were reported in the records of the Office of theSurgeon General following World War I. The present study of 3154 wounds involving the abdomen revealed 27 incidents of ureteral trauma.

TABLE I

Incidence of Ureteral Involvement in 3154 Abdominal Wounds

GROSS TOTAL			COMPLICATED CASES			UNCOMPLICATED CASES		
Total Cases	Incidence in 3154 Cases	Mortality	Incidence	Deaths	Percent Mortality	Incidence	Deaths	Percent Mortality
27	0.8%	40.7%	26	11	42.3%	1	0	0

With one exception every wound to the ureter was complicated by wounding to other abdominal structures. The single uncomplicated wound was from a fragment which caused a small laceration of the upper ureter without any other injury.

Pertinent Data in 27 Wounds to the Ureter Among 3154 Abdominal Cases.

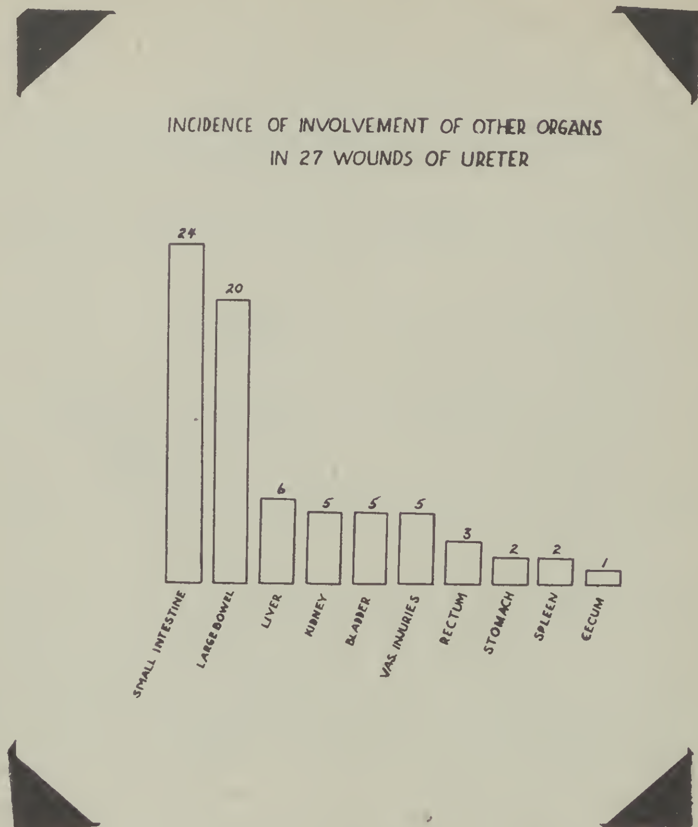

Figure 55 - Incidence of Involvement of Other Organs in 27 Wounds of Ureter

TABLE II

Frequency of Wounds to Other Organs Complicating Injuries to the Ureter

Organs Complicating	Incidence
Small Intestine	21
Large Intestine	18
Bladder	6
Liver	6
Kidney	5
Duodenum	4
Rectum	4
Major Abdominal Blood Vessels	4
Stomach	2
Spleen	2

Pertinent Data in 27 Wounds to the Ureter Among 3154 Abdominal Cases.

Of the complicating injuries involving the ureter, that to the small intestine was the most common, this organ being involved 21 times. (Figure 55). The large intestine was wounded 18 times. Wounding to these two represented more than one half of the complicating wounds. The incidence of involvement of other abdominal structures dropped markedly. Injuries to major blood vessels of the abdomen occurred in four instances with ureteral wounds. There were two deaths among the four. One died 48 hours after surgery from multiple pulmonary and coronary emboli from the inferior mesenteric vein.

The other died on the seventh postoperative day of generalized peritonitis. The ureteral repair had not broken down. None of these injuries involved a vessel larger than the internal iliac vein.

There were no anomolies of the ureter found at operation or postmortem.

The diagnosis of ureteral involvement in abdominal wounds is not easily made preoperatively. There was record of but three instances of hematuria where the bladder or kidney were not involved. The diagnosis was made in practically every instance through exploration of the wound. We have not been able to diagnose ureteral wound by the detection of the presence of urine on dressings or in the wound. Cystoscopy and intravenous urography were not used.

TABLE III

Operative Procedures Employed in 27 Ureteral Wounds

Operative Treatment	Number
Vesicle Transplant	6
Nephrectomy	5
Telescoping Anastomosis	4
Ligation Both Ends of Ureter	3
Suture of Laceration	2
End-to-End Ureteroanastomosis	2
Drained Only	2
Overlooked	2
Cutaneous Ureterostomy	1
TOTAL	27

Operative treatment of these cases was extremely varied. Reimplanatation into the bladder was done six times. One of the six separated on the third postoperative day and was successfully re-operated upon. In five instances, nephrectomy was done because of severe renal injury. Telescoping ureteroanastomosis was performed on four

Pertinent Data in 27 Wounds to the Ureter Among 3154 Abdominal Cases.

occasions. Three were successful. End-to-end ureteroanastomosis was done without ureteral catheterization or nephrostomy in two instances. Both patients died of shock within 48 hoursfrom mortal wounds.

Two lacerations were successfully sutured. Cutaneous ureterostomy was done on one occasion. Destruction of a considerable segment did not permit repair and the condition of the patient did not warrant extension of operating time to perform nephrostomy.

Two instances of drainage to suspected ureteral damage were found. One of these was in a case where the ureteral laceration was not discovered until necropsy.

There were two recorded instances of overlooked ureteral damage. Both cases failed to survive. The lacerations were cited as contributory causes to death.

It was an accepted practice among surgeons of this Group to expose the ureter whenever the missile had passed along its course.

Ligation of the ureter in transecting wounds with destruction over same distance was done on three occasions. In but one case was there complicating renal damage. The mortality rate among 27 ureteralwounds was 40.7%. How much the two overlooked incidents contributed toward the death of the patients was not clearly stated. However, we can presume they played an extensive contributing if not a principal role. Nephrostomy or ureterosigmoidostomy was not done in any of the wounds of this series. Ureteral catheters were not included in supply to forward surgical installations. Had they been supplied they might have stimulated more extensive surgery to the ureter with better results. Black silk was the suture of choice in all uretero-anastomoses, while chromic catgut was used in the vesicle re-implantations. Eight of the deaths (72.7%) occurred within 72 hours of wounding from shock.

SUMMARY

1. A study was made of 27 instances of ureteral wounds among 3154 abdominal cases.

2. The small and large intestine constituted more than 50% of the complicating wounds.

3. There was but one instance of uncomplicated ureteral wound.

4. Reimplantation into the bladder, telescoping anastomosis, and

Pertinent Data in 27 Wounds to the Ureter Among 3154 Abdominal Cases (Summary, cont'd)

suture of lacerations were performed six, four, and two times, respectively.

5. There were 11 deaths among the 27 cases with a mortality rate of 40.7%.

REFERENCES

1. A Study of 427 Wounds to the Kidney in 3154 Abdominal and Thoraco-abdominal War Injuries. (page 356 of this Report).

WOUNDS OF THE URINARY BLADDER

An Analysis of 155 Cases.

In the period 1 January 1944 to 8 May 1945, the surgical teams of the 2nd Auxiliary Surgical Group, functioning in Italy, France, and Germany, operated on 3154 wounded individuals having abdominal pathology. One hundred fifty-five of these (4.9%) had bladder lesions. There were 19 additional cases with bladder lesions operated on in the period 8 November 1942 to 31 December 1943, but these are not included in this report because insufficient data are available on these early cases of the African and Sicilian Campaigns. These 155 cases were operated on by approximately 39 different teams.

The diagnosis of a bladder lesion is not difficult. The path of the missile, as determined from an alignment of the wounds of entrance and exit, or from the wound of entrance and the location of the foreign body as seen on the X-ray film, indicates whether the bladder may have been involved. Fractures of the bony pelvis merit investigation, and in the occasional case, pressure or blast will damage the bladder. In this series of cases the most frequent sites of entry of the missile were through the buttocks (56 times) and anterior abdominal wall (56 times). Other sites of entry were through the thigh, hip, perineum, back and flank. Approximately one third of the cases had wounds of exit, the missile having left the body. The missile was retained in the other two-thirds. There is nothing characteristic in the abdominal physical findings. Tenderness, rigidity and peristalsis depend to a large measure on the complicating intra-abdominal lesions and the amount of intra-abdominal or retroperitoneal hemorrhage. The presence of a urinary fistula indicates damage to some portion of the genito-urinary tract as does hematuria. Clear, normal urine does not eliminate bladder damage. Five of these 155 cases with lesions of the bladder had no blood in the urine. Six cases had a urinary fistula before operation. Filling the bladder with some solution prior to surgery for diagnositic purposes is not recommended. More contaminated material may be forced into the peritoneal cavity, but more important, extravasation of infected fluid may occur retro- and infraperitoneally. Most of these cases had other abdominal lesions reouiring laparotomy, so it was thought preferable to wait until the abdomen was opened before instilling saline through a urethral catheter. This procedure was not employed by all surgeons. In these 155 cases, the correct diagnosis was made preoperatively or at surgery 149 times. Six cases were overlooked: Two of these died the first postoperative day and the bladder wounds were found at autopsy. Three of the six developed urinary fistula (thigh, abdominal wound, and rectal) and were later subjected to cystostomy with satisfactory results. In the sixth overlooked case, bladder injury was suspected, but could not be demonstrated at operation. An indwelling catheter was left in the bladder for six days postoperatively. Following removal of the catheter, a small foreign body was passed by urethra. Recovery was uneventful.

Wounds of the Urinary Bladder (contd)

In considering mortality in bladder wounds, it is necessary to realize the high incidence of complicating intestinal pathology. One hundred and thirty-four of the 155 cases (88%) had bowel lesions in addition to the bladder damage. In these cases, the gastro-intestinal tract injuries merited and received primary consideration. Even in some which did not involve the bowel, hemorrhage from the pelvic blood vessels was of more serious import than the bladder injury, and certainly presented a greater technical problem. All deaths which occurred in cases with bladder damage were complicated by intestinal injury. The mortality rate in cases having bladder leions depends mainly on how much bowel damage co-exists. (Table I and Table II) There were no deaths in cases with uncomplicated bladder wounds. This seems to indicate that uncomplicated bladder lacerations which are operated on promptly are not life-threatening, but it is significant that a multiplicity of lesions increases mortality. The mortality rate for 353 cases with only small bowel lesions operated upon by this Auxiliary Surgical Group was 14%. If the bladder was involved along with small bowel (40 cases) the mortality rate was 22%. Similarly the percentage mortality for 251 cases with only colon lesions was 23%. For colon and bladder lesions coexisting it was 43%.

TABLE I

Percentage Mortality in Wounds of the Bladder With and Without Complicating Bowel Lesions

	No. Cases	Deaths	Mortality
Total cases with bladder lesions	155	46	30%
Bladder lesions with complicating bowel lesions	134*	46	34%
Bladder lesions without complicating bowel lesions	21	0	0%

* 55 of these 134 involved rectum

TABLE II

Percentage Mortality in Wounds of the Bladder with Complicating Bowel Lesions

Location of Bowel Wound	No. Cases	Deaths	Mortality
Extraperitoneal Rectum only	6	1	17%
Intraperitoneal Rectum only	17	3	18%
Small Bowel only	40	9	22%
Colon only (excludes rectum)	21	9	43%
Both Large and Small Bowel	50	24	48%

Wounds of the Urinary Bladder (contd)

The shock-mortality relationship followed the usual pattern. The greater the degree of shock on admission to the hospital, the higher was the mortality rate (mortality rate: 8% no shock; 25% moderate shock and 63% severe shock).

Thirty-five cases were wounded by gunshot with a mortality of 34%. Seventy-one cases were wounded by shell fragment with a mortality of 32%. There were three cases of bladder injury classified as due to blunt trauma, with no deaths. In 46 cases the agent causing injury was not recorded.

One hundred and thirty-seven of the 155 cases had an intraperitoneal laceration of the bladder. Nine cases had only an extraperitoneal laceration and none of these died. Nine cases had a severe contusion without a laceration. These last nine all had serious other intra-abdominal lesions and three of them died.

Surgical procedures carried out for bladder wounds varied very little. One hundred and ten cases had suprapubic cystostomy with repair of the laceration; 13 cases had suprapubic cystostomy without repair; six cases had repair without any other procedure; three cases had an indwelling urethral catheter placed; six cases were overlooked; seven cases died on the operating table. There are no data available concerning the type of surgery done on 10 cases. Repair of the laceration with suprapubic cystostomy was the procedure of choice. The abdomen was opened to explore and repair what other intraperitoneal injury was present and the intraperitoneal bladder was thus easily inspected and repaired. After closing the peritoneum and in doing the suprapubic cystostomy, the extraperitoneal portion of the bladder was inspected and repaired. The space of Retzins was routinely drained. In this series, sulfonamides were occasionally used in the abdomen or wound and in the later cases, penicillin was at times used intra-abdominally. Postoperatively, all patients received sulfonamides orally or intravenously, penicillin intramuscularly, or both. Three of the nine patients with severe bladder contusions were treated by suprapubic cystostomy (one died) and six received no bladder treatment (two died).

The 109 living cases were followed for from one to 20 days, depending on the tactical situation. Only 25 cases were followed less that five days. There were 17 postoperative complications (Table III) but there was no infection of the paravesicular tissue in any case that lived. There was one retroperitoneal cellulitis in a case that died.

The 46 deaths are analyzed in Table IV. All deaths occurred in cases which had complicating bowel lesions. Early deaths were largely due to shock. Chest complications, urinary suppression, and peritonitis were important as principal causes of death after the third postoperative day. There were three deaths due to gas gangrene of extensive associated wounds.

Wounds of the Urinary Bladder (contd)

TABLE III

Postoperative Complications, 109 Surviving Cases with Bladder Lesions (17 Complications)

Atelectasis	3	Secondary Hemorrhage	1
Pneumonia	1	Pyelitis	1
Cardiac Failure	1	Epididymitis	1
Fever, unspecified	1	Infected Laparotomy Wounds . (one later eviscerated)	3
Fecal Fistula	2	Subphrenic Abscess	1
Urinary Fistula	1	Abscess, unspecified	1

TABLE IV

Analysis of Deaths by Day and Causes

Day of Death	Causes							Total
	Unknown	Misc*	Shock	Peritonitis	Chest Complications	Anuria	Embolism	
Operation	1	4	9	1			1	16
1st Postoperative			2	1				3
2nd "	1		4	3	2	1		11
3rd "	1	1		1	1	1		5
4th "		1		1	1	2	1	6
5th "							1	1
6th-8th "	1	1			1		1	4
Totals	4	7	15	7	5	4	4	46

* Miscellaneous deaths: 3 gas gangrene; 2 anesthesia (not definite); 1 heart lesion; 1 retroperitoneal cellulitis.

SUMMARY

Data are presented on 155 cases of bladder lesions incurred as war wounds. The physical findings, shock-mortality relationship and wounding agents are presented. The significance of hematuria is discussed but cases are listed in which bladder lesions occurred without any blood being present in the urine

The high incidence of complicating intestinal pathology is shown All deaths occurred in cases which had bowlel lesions in addition to the bladder wound. None of the patients with bladder lesion uncomplicated

Wounds of the Urinary Bladder (contd)

by a bowel lesion died, indicating that bladder lesions, promptly operated up, are not necessarily life-threatening. It is shown that the mortality rate for small and large bowel lesions is considerably raised by having a complicating bladder injury, indicating the grave significance of a multiplicity of lesions. The threatment of choice has been the establishment of bladder drainage by a suprapubic cystostomy with repair of the laceration. The space of Retzius was routinely drained and sulfonamide and/or penicillin were used both locally and systemically. Only one case developed postoperative paravesicular infection. The complications and principal causes of death which are presented, are more related to the complicating bowel lesions than to the urinary track.

WOUNDS OF THE URETHRA

In the period 8 November 1942 to 8 May 1945 there were 43 urethral lacerations operated on by the teams of the 2nd Auxiliary Surgical Group. Most of these 43 had other serious lesions or they would not have been cared for by this Group. In 10 of these 43, the bladder was also perforated.

It is not difficult to diagnose a lacerated urethra. Wounds of the penis, scrotum or perineum are to be especially suspected of having co-existant urethral tears. Bleeding from the penis or blood in the first portion of the urine are frequent findings. The inability of the wounded to urinate associated with difficulty in passing a urethral catheter indicates a urethral lesion. Simultaneous rectal palpation and the passage of a urethral catheter may give valuable diagnostic information.

In the 43 recorded cases of urethral wounds, there were six deaths. All these six had serious other complicating wounds as follows:-

1. Lacerated rectum, sucking thoracic wounds.
2. Bilateral sucking thoracic wounds.
3. Lacerations, small and large bowel.
4. Hemorrhage left common iliac artery and vein.
5. Laceration small and large bowel.
6. Extensive multiple soft tissue wounds.

Primary treatment of urethral wounds has been satisfactorily accomplished by the establishment of bladder drainage through a suprapubic cystostomy. The placement of an indwelling urethral catheter can usually be accomplished when the bladder is opened, by simultaneous manipulation from above and below. If this can be accomplished at the primary operation, any necessary secondary procedures are made easier. Suture of the urethra was seldom done (five times), the employment of a catheter splint usually being considered satisfactory. Thirty-five of the 43 cases were treated by suprapubic cystostomy and in 18 of these, an indwelling urethral catheter was also placed. The other eight cases were treated only by an indwelling catheter.

SUMMARY

Relatively few urethral wounds were treated by teams of the 2nd Auxiliary Surgical Group, for unless they had other serious lesions they did not come to units at which this group functioned. The six deaths in the 43 treated cases can all be attributed to other serious lesions. Diagnosis of urethral tears is not difficult and depends on wound location, bleeding from the penis, and the ease with which a

Wounds of the Urethra (Summary, cont'd).

urethral catheter can be passed. Treatment is best accomplished by a suprapubic cystostomy and the passage of an indwelling urethral catheter to act as a splint during healing. It has occasionally been deemed necessary to suture the urethra (five cases only of these 43).

ABDOMINAL VASCULAR INJURIES

In the 3154 abdominal and thoraco-abdominal cases operated upon by the 2nd. Auxiliary Surgical Group in the years 1944 and 1945, 75 cases were encountered in Field Hospitals in which one or more great vessels of the abdomen were injured. This report is based on a statistical analysis and appraisal of these 75 cases. There are instances of other intra-abdominal vascular injuries such as severance of a colic artery, a splenic artery, or a renal pedicle, which have been purposely omitted from this report. These visceral vascular lesions have been delegated to the sections dealing with injury to those abdominal organs. Only injuries to the great vessels have been considered.

Table I

Incidence of Vascular Injuries of the Abdomen

	Total No. of cases	Lived	Died	Mortality
I. Vein Injury (Single Vein)	38	11	27	71%
II. Combination Two or more Veins	8	1	7	87.5%
III. Combination Vein and Visceral Vascular Lesion	7	0	7	100%
IV. Arterial Injuries	13	5	8	62.0%
V. Combination Artery and Vein	9	3	6	66.6%

Total Great Vessel Injuries = 75

Lived 20 = 27%
Died 55 = 73%

The inferior vena cava, common, internal, and external iliac veins, and portal vein comprise the vein injuries.

The common, internal, and external iliac arteries make up the group of arterial injuries, while these same vessels with their corresponding veins make up the combination artery and vein injuries.

No instances of injury to the abdominal aorta survived to have surgery in the Field Hospital.

TABLE II

Relation of Clinical Shock at the time of Admission to Field Hospital to Mortality

	No. Cases	Lived	Died	Percent Mortality
4+ Shock	39	6	33	85%
3+ Shock	8	2	6	75%
2+ Shock	16	6	10	62.5%
1+ Shock	2	1	1	50%
No Shock	4	2	2	50%
Not Recorded	6	4	2	33.3%

Inasmuch as the blood pressure and pulse on admission to the Field Hospital were not recorded in many of these cases, we have related the mortality to the degree of clinical shock. The latter was often a more accurate index to the degree of shock than the blood pressure alone. It represents the surgeon's impression of the severity of shock taking into account these factors: (1) general appearance of the patient (2) blood pressure (3) rate and quality of the pulse. Very severe shock (usually with no blood pressure or pulse obtainable) was classified as 4+; moderately severe shock was 3+; moderate shock as 2+; mild shock as 1+. A perusal of the above table (Table II) indicates that the mortality is directly parallel to the severity of shock on admission.

TABLE III

Causes of Death in 55 Cases

	No. Cases	Percent
Hemorrhage and Shock	27	49%
Anuria	12	22%
Pulmonary Embolism	4	
Pneumonia	3	18%
Pulmonary Edema	3	
Peritonitis	2	
Gas Infection (Extremities)	2	11%
Retroperitoneal Suppuration	1	
Cause Unrecorded	1	

Relation of Time-Lag to Mortality

The time-lag as we have considered it is the time elapsing from the time of injury until the time of surgery. We arbitrarily divided it into six hour periods. The majority of patients received surgical treatment within 12 hours of injury. No significant data otherwise were obtained by this study.

Multiplicity Factor in Mortality

Table IV shows a computation of the mortality rate without any abdominal viscus being injured, and also in conjunction with injury to one, two, three, four and five organs. The mortality rate is higher where no abdominal viscera are involved than where one organ is injured. Other than for this one discrepancy, there is a gradual rise in mortality rate with the increase in number of abdominal organs injured. In a comparison of the multiplicity factor for abdominal cases in general with these 75 abdominal cases having an injury to one or more great vessels, it can be seen that the greatest factor in the consistently high mortality rate of the latter group is the injury to the great vessel itself.

Abdominal Vascular Injuries cont'd.

Table IV

Multiplicity Factor in Mortality (75 Cases) in Wounds of the Great Vessels of the Abdomen

	Total	Lived	Died	Mortality	% Total Mortality	% Total Cases
No organ	8	3	5	62.5%	9.1%	10.6%
One organ	22	10	12	54.5%	21.8%	29.3%
Two organs	21	4	17	81%	30.9%	28.0%
Three organs	13	2	11	84.6%	20%	17.3%
Four organs	1	0	1	100%	1.8%	1.3%
Five organs	2	0	2	100%	3.6%	2.6%
No record	8	1	7	87.5%	12.7%	10.6%
Total	75	20	55	73%	100%	All

Table V

Table Showing Comparison of Multiplicity Factor for Abdominal Cases in General and 75 Abdominal Cases with Great Vessel Injury.

	All Abdominal Cases Mortality %	Abdominal Cases with Great Vessel Injury Mortality %
One organ	12%	54.5%
Two organs	26.6%	81%
Three organs	46%	84.6%
Four organs	60.6%	100%
Five organs	83.3%	100%

Group I. Injuries of the Great Veins of the Abdomen.

Injury to a single great vein of the abdomen occurred in 38 cases. For statistical study, we have divided these great vein injuries into two groups: (1) inferior venae cavae alone, and (2) veins other than inferior venae cavae.

Abdominal Vascular Injuries cont'd.

Table VI

Surgical Management of Great Vein Injuries

A. Inferior Venae Cavae Alone; 22 Cases

Surgical Management	No. of Cases	Lived	Died
Vein ligation	12	3	9
Vein suture	6	2	4
Vein clamped tangentially	1	0	1
Vein uncontrolled	3	0	3
Total	22	5	17

Total Cases Died - 17 - 77%
Total Cases Lived - 5 - 23%

B. Great Veins Other Than Venae Cavae. - 16 Cases

	No. of Cases	Surgical Management	Lived	Died
Common iliac	6	Ligation 5, Packed 1	2	4
Internal iliac	2	Ligation 2	1	1
External iliac	5	Ligation 5	3	2
Portal vein	2	Uncontrolled 1 Packed 1	0	2

Total Cases Died - 10 - 62.5%
Total Cases Lived - 6 - 37.5%

Abdominal Vascular Injuries cont'd.

Table VII

Group II. Combination of Injuries to Two or More Great Veins - Eight Cases

Inferior Vena Cava involved five times - one case lived - four cases died.

	No. of Cases	Surgical Management	Lived	Died
Inferior Vena cava Common iliac vein	3	Ligated 1 Sutured 1 Uncontrol-led - 1	0 1 0	1 0 1
Inferior vena cava Portal vein Hepatic artery	1	Uncontrol-led - 1	0	1
Inferior vena cava Both common iliac veins Right internal iliac vein	1	Ligation	0	1
Left common iliac vein Left internal iliac vein	1	Ligation	0	1
Right common iliac vein Right internal iliac vein	1	Ligation	0	1
Right external iliac vein Right internal iliac vein	1	Ligation	0	1

Total - 8 Cases

Total Lived - 1 - 12½%
Total Died - 7 - 87½%

Table VIII

Group III. Combination Great Vein Injury and Visceral Vascular Lesion

Total No. of Cases - 7. All 7 Cases died. Mortality - 100%

3 Cases - Inferior vena cava and right renal pedicle:
- 1 case - Inferior vena cava sutured and right nephrectomy.
- 1 case - Inferior vena cava ligated and right nephrectomy
- 1 case - Inferior vena cava uncontrolled and right renal pedicle uncontrolled.

Abdominal Vascular Injuries Table VIII cont'd.

1 Case - Inferior vena cava plus right gastric artery and vein; inferior vena cava uncontrolled; gastric artery and vein ligated.

1 Case - Inferior vena cava (spontaneous thrombosis) and hepatic artery ligated.

1 Case - Inferior vena cava (ligated) plus superior messentric artery sutured.

1 Case - Portal vein and hepatic artery (packed).

Table IX

Summary of All Vena Cava Injuries

A.

	No. of cases
Inferior vena cava alone (single vascular injury of abdomen)	22
Inferior vena cava plus other great vein injuries	5
Inferior vena cava plus visceral vascular injuries	6

Total vena cava injuries - 33-Lived 6 (18%) - Died 27 - (82%).

B. Surgical Management of 33 Inferior Vena Cava Injuries

	No. of Cases	Lived	Died
Ligation	16	3	13
Suture	8	3	5
Tangential Clamping	1	0	1
Spontaneous Thrombosis	1	0	1
Uncontrolled	7	0	7

Surgical management of the six cases that survived to be evacuated from the Field Hospital:

Vessel Sutured - 3 cases - below renal veins
Vessel Ligated - 3 cases - below renal veins

In two cases, one of which eventually died of massive pulmonary embolism, swelling of the lower extremities was noted. In the latter case the inferior vena cava had been sutured, - not ligated.

Abdominal Vascular Injuries, Table IX cont'd.

In two cases distention of the veins of the lower extremities was noted, following ligation of the vena cava in one and suture in another. In the latter case, spontaneous thrombosis probably occurred subsequently at the site of injury and repair.

No case in which the inferior vena cava was ligated or sutured above the renal vessels survived. There were eight of these cases, six of which were handled by ligation, one by suture, and one by tangential clamping.

Table X

Group IV. Arterial Injuries (alone) - 13 Cases

A. Tabulation of 13 Arterial Injuries in Relation to Mortality

	No. of Cases	Lived	Died
External iliac artery	6	2	4
Internal iliac artery	3	1	2
Common iliac artery	4	2	2

Total arterial injuries alone - 13
Lived - 5 cases - 38%
Died - 8 cases - 62%

B. Surgical Management of Arterial Injuries

	No. of cases	Vessel Ligation	Lived	Died	Vessel Suture	Lived	Died
External iliac artery	6	5	1	4	1	1	0
Internal iliac artery	3	3	1	2	0	0	0
Common iliac artery	4	2	0	2	2	2	0
Total	13	10	2	8	3	3	0

C. Summary of Surgical Management in Relation to Mortality.

	No. of Cases	Lived	Died
Arterial injuries ligated	10	2	8
Arterial injuries sutured	3	3	0

In two cases with injury to the external iliac artery which required ligation, the external iliac vein was electively ligated. One of these cases developed vascular insufficiency of the corresponding lower extremity, necessitating amputation, while one did not.

Abdominal Vascular Injuries, Table X cont'd.

Vascular insufficiency of the lower extremities occurred in three out of these 13 cases, in all instances following vessel ligation.

(1) External iliac artery injury (artery and vein ligated) Leg demarcating at mid-calf when patient died on 3rd P.O. day of anuria and overlooked retroperitoneal injury of the cecum.

(2) External iliac artery injury (artery only ligated) Amputation necessary left mid-thigh on 7th P.O. day because of gangrene due to arterial insufficiency plus gas gangrne of the extremity.

(3) Common iliac artery injury (artery and vein ligated) Amputation subsequently necessary in thigh on corresponding side. Patient eventually died of gas infection in this stump.

Group V. Combination Artery and Vein Injuries - 9 cases.

The combined injury of a great artery and a great vein occurred in nine cases and in all instances involved corresponding iliac vessels in the pelvis.

Table XI

A. Tabulation of Nine Combined Artery and Vein Injuries in Relation to Mortality.

	No. of Cases	Lived	Died
External iliac artery and vein	2	1	1
Internal iliac artery and vein	6	2	4
Common iliac artery and vein	1	0	1

Lived - 3 cases - 33.3%
Died - 6 cases - 66.6%

In nine combined artery and vein injuries, eight cases had vessel ligation while one case was handled by clamping only.

Abdominal Vascular Injuries, Table XI cont'd.

B. Surgical Management of Combined Artery and Vein Lesions

	No. of Cases	Vessel Ligation	Lived	Died	Vessel Clamped	Lived	Died
External iliac artery and vein	2	2	1	1			
Internal iliac artery and vein	6	5	2	3	1	0	1
Common iliac artery and vein	1	1	0	1			

Total Vessels clamped - 1 Died - 1
Total Vessels ligated - 8 Died - 5 Lived - 3

Vascular insufficiency of the corresponding lower extremity occurred in two of these nine cases with combined artery and vein injury.

(1) Injury to left external and internal iliac veins and left internal iliac artery. (All vessels ligated).
Left leg mottled and cold 12 hours postoperatively. Patient died 40 hours postoperatively in shock from severe peritonitis before amputation of extremity was necessary.

(2) Injury to the left common iliac artery and vein (both vessels ligated).
Developed gangrene of left lower extremity and required amputation of left thigh on 4th P.O. day.

COMMENT

It has been pointed out that the frequency of injury to any abdominal viscus is directly proportional to the space occupied by that viscus, Page 93. Reasoning along these lines, it is obvious that injury to the corresponding great arteries and veins should occur with approximately the same frequency inasmuch as these vessels approximate each other in size. A review of our 75 cases with injury to one or more great vessels of the abdomen shows that 53 cases (77%) involved one or more veins, whereas 22 cases (23%) were arterial injuries alone, or associated with injury to the corresponding vein. This is not a disparity in incidence of injury between arteries and veins, but, rather, a disparity in lethality between the two. Fewer arterial injuries survived to have surgical treatment in the Field Hospital. This is further borne out by the fact that 33 Vena Cava lesions were treated while no lesions of the abdominal aorta survived to have surgery. The overall mortality for all arterial injuries was 64% as compared to an overall

rate of 77% for the veins. Even cases with severe injury to the great veins managed to reach the hospital alive apparently because a point was reached in the process of bleeding whereby the intra-abdominal tension rose sufficiently high and the venous pressure dropped sufficiently low to prevent complete exsanguination and death. This must have occurred with much less frequency in arterial injuries and fewer of these patients were received. The lower mortality rate for arterial lesions that actually received surgical treatment must be attributable to the unusual circumstances that allowed these patients to reach the Hospital alive in the first place. These injuries were probably minimal, the blood loss less before surgery, and the bleeding controlled with greater rapidity after the abdomen was opened.

The overall mortality for injury to the great vessels in this series whether, artery or vein, or combination thereof, is 73%. It carries the highest mortality rate in war incurred injuries of the abdomen. No problem so challenges the technical skill of the surgeon as the ability to control severe hemorrhage in the abdomen with sufficient rapidity to allow the patient a chance to recover.

RETROPERITONEAL HEMATOMA

Retroperitoneal hematoma is defined as any extravasation of blood, whether circumscribed or diffuse, into the retroperitoneal areolar tissues. In 3154 abdominal and thoraco-abdominal cases operated upon in 1944 and 1945, retroperitoneal hematoma was frequently encountered. We are unable to give the exact incidence with which it occurred because of the relative infrequency with which the surgeon recorded it. Any missile which penetrated or perforated the retroperitoneal space almost invariably produced a hematoma of some degree. Not all cases resulted from direct penetration because some of the recorded instances resulted from blunt injury to the abdomen. The majority of these cases were well-handled surgically but some few errors occurred which will be pointed out. Many required no particular treatment and were of little or no pathological significance. The adoption of an attitude that most of them could be handled in this manner led to the oversight of existing lesions which resulted in the loss of life.

At the outset, it may be stated with certainty that clinical recognition of the existence of a retroperitoneal hematoma cannot be made prior to surgical exploration. It can be stated with equal assurance that clinical differentiation between the existence of a retroperitoneal hematoma and a visceral injury cannot be made prior to surgery. The signs and symptoms of each may be identical, and frequently both lesions are present in the same patient. In this connection, it is of interest to note that a retroperitoneal hematoma alone was the only pathology in 59 cases which had otherwise negative abdominal exploration. All 59 of these cases presented the signs of an acute abdomen with tenderness, spasm and often rigidity. There were four deaths subsequently from these 59 explorations, a mortality rate of 6.8%. The cause of death in these four cases was as follows:

(1) Pulmonary embolism - 1 case.

(2) Asphyxia from aspiration (anesthetic death, died on table) - 1 case.

(3) Pneumonia, both lower lobes - 1 case.

(4) Retroperitoneal cellulitis and thrombosis left renal vein - 1 case.

In addition to presenting the signs of an acute surgical abdomen, 16 of these 59 cases presented clinical shock of some degree on admission.

Retroperitoneal Hematoma.

TABLE I

Showing Clinical Shock on Admission in Relation to Mortality in 59 Cases of Retroperitoneal Hematoma With Otherwise Negative Abdominal Explorations

Clinical Shock	Lived	Died
4 Plus - 1 Case	1	0
3 Plus - 2 Cases	1	1
2 Plus - 6 Cases	5	1
1 Plus - 7 cases	7	0
None - 25 Cases	24	1
Not Recorded - 18 Cases	17	1
TOTAL - 59 Cases	55	4

In general, it has appeared that this group of cases presented less shock than is usually encountered in a group of similar size with intraperitoneal injury to a single solid or hollow viscus.

We have been unable to verify the existence of the retroperitoneal syndrome described by Jolly[1] following his experiences in the Spanish Civil War. This syndrome, as he described it, consisted of a state of shock with generalized pallor and sweating; a rapid thready pulse often becoming imperceptible; the complete absence of abdominal tenderness and spasm (in fact, no abdominal signs); and, in some cases, a semi-erection of the penis, which, when it occurred, was of grave prognostic significance and, once it had appeared, usually persisted until the death of the patient. The underlying pathology was said to be a retroperitoneal infiltration of blood about the coeliac plexus. In the 3154 abdominal and thoraco-abdominal cases operated upon by surgeons of this Group, we have not encountered a syndrome resembling this. As we have pointed out, the signs and symptoms of retroperitoneal pathology and hematomas have been indistinguishable at times from those resulting from perforation of a hollow viscus. The presence of priapism, in our experience, has usually been associated with injury to the spinal cord; in the infrequent instances in which it has been associated with retroperitoneal hematoma, it has not implied a grave prognosis.

The presence of retroperitoneal hematoma is recorded in only 207 cases from our entire series. This does not begin to represent the

Retroperitoneal Hematoma.

true incidence of occurrence, but rather, the incidence only with which the surgeons made it of record. As proof of this, we know that there were 427 kidney injuries in all of which there were retroperitoneal hematomas of varying degree. Likewise, we had 75 instances of injury to one or more great vessels of the abdomen, all of which traverse the retroperitoneal space. Undoubtedly, all of these cases had retroperitoneal hematomas, but accurate written record of such was made in only 33 cases. These two groups alone total roughly 500 cases. When we add to this the number of duodenal, colon, ureteral and bladder injuries which do not overlap with each other or with the aforementioned kidney and vascular injuries, we can be assured that the 207 recorded cases represent only a fraction of the total and that retroperitoneal hematomas are among the most frequently encountered lesions in abdominal explorations for war-incurred injuries.

In 11 of our 207 recorded cases diagnosis only of retroperitoneal hematoma was made and no treatment, presumably, was necessary. An additional 63 cases were so diagnosed and the majority of these were drained only; some few had evacuation of clots plus drainage; while an occasional case required packing to control bleeding that was not readily controlled otherwise. Thirty-three out of 75 cases with injury to one or more great vessels of the abdomen were diagnosed as having retroperitoneal hematomas. The treatment in these cases consisted of retroperitoneal exploration, evacuation of the blood, and control of the bleeding vessel in one of three ways: by ligation, suture of the vessel, or clamping.

TABLE II

Mortality in 207 Cases in Relation to the Method of Treatment of the Retroperitoneal Hematoma.

Group		Died
I	111 Cases retroperitoneal hematomas, no treatment	19
II	63 cases retroperitoneal hematoma, drained, packed, or clot evacuated and drained; or ligation of other than great vessels	22
III	33 cases retroperitoneal hematoma associated with great vessel injury of abdomen	22

In Group I, the 19 deaths which occurred were apparently unrelated to the retroperitoneal hematomas and attributable to the associated intra-peritoneal pathology.

In Group II, 22 deaths occurred, in half of which (11 cases) the cause of death was directly referable to the pathology in the retro-

Retroperitoneal Hematoma.

peritoneal space:

5 cases - died of shock and hemorrhage as a direct result of severe retroperitoneal bleeding not originating from great vessels.

3 cases - died subsequently from anuria following severe shock from retroperitoneal bleeding.

2 cases - died of retroperitoneal cellulitis.

1 case - died of retroperitoneal cellulitis and pulmonary embolism.

In Group III, the 22 deaths which occurred were directly related to the causes of death in general for injuries to the great vessels of the abdomen. (See discussion on abdominal vascular injuries, Page 385

The real significance of a retroperitoneal hematoma, other than for the clinical signs which are indistinguishable from those of viscus perforation lies in the fact that it may obscure injury to vital retroperitoneal structures. We have recorded two instances of overlooked duodenal perforation with two deaths; two overlooked ureteral injuries with one death; four overlooked retroperitoneal colon injuries with three deaths; and six overlooked bladder injuries with two deaths. As we have stated previously, many small and insignificant retroperitoneal hematomas do not require exploration or drainage. Excessively large hematomas, or those that give evidence of continued bleeding must be explored and the bleeding vessel controlled. It is easy under these circumstances which necessitate control of severe hemorrhage, and in the presence of a larger hematoma, to overlook a co-existing lesion such as a retroperitoneal colon perforation. One such case was reported. We strongly urge the necessity for careful exploration of the surrounding structures after a large hematoma has been evacuated and the hemorrhage brought under control. Likewise, we urge the exploration of the retroperitoneal space in the presence of a hematoma of any size if the anatomical location is such as to suggest possible injury to the ureter, posterior aspect of the colon, duodenum, or bladder. We advocate satisfactory extraperitoneal drainage for retroperitoneal hematomas associated with injury to any portion of the urinary tract (kidney, ureter, or bladder), in injuries to the pancreas, or in any lesion of the colon which has resulted in heavy contamination retroperitoneally. This should be made, if necessary, through a freshly made drainage incision in the flank or posteriorly assuming that a debrided wound of entry or exit does not exist that can be utilized for this purpose. In large hematomas with vascular injuries, we believe that the evacuation of the clot when possible and ligation of the bleeding vessels is usually sufficient. Any opening in the posterior peritoneum, whether made by the missile or operating surgeon, should be carefully re-

Retroperitoneal Hematoma.

peritonealized to eliminate communication between the peritoneal cavity and the retroperitoneal space.

REFERENCES

1. Jolly, Douglas W.: Field Surgery in Total War. Page 176. Paul B. Hoeber Inc., New York, 1941.

PART II ABDOMINAL INJURIES OF SPECIAL TYPES

Injuries of Abdominal Viscera Without Penetration of Peritoneum

Associated with Open Wounds

Due to Blunt Trauma and External Blast

Wounds Penetrating the Peritoneal Cavity Without Visceral Injury

INJURIES OF ABDOMINAL VISCERA WITHOUT PENETRATION OF PERITONEUM

Associated with Open Wounds

Thirty-one hundred and fifty four (3154) patients with abdominal and thoraco-abdominal wounds and injuries were operated upon in forward hospitals by teams of this Group during the period 1 January 1944 to 8 May 1945. Only 12 cases of open wounds were recorded in which significant injury to intra-peritoneal viscera occurred without penetration of the peritoneum by the wounding missile. Nine of the wounds involved the abdomal wall; one involved the chest wall and diaphragm, one the left chest wall and adjacent abdominal wall and one the chest wall only. The wounding agent was listed as high explosive shell fragment in eight cases; it was not recorded in the other four. The one fatal case sustained a severe penetrating wound of the left chest. The missile lacerated the pleural surface of the left dome of the diaphragm, apparently denting it against the stomach wall to produce a subserosal hematoma there. Damage to the lung was extensive and the patient died postoperatively of shock and pulmonary edema. The intra-abdominal injury played no significant part in the death.

The wounds perforated the extra-peritoneal abdominal wall in 10 of the 12 cases. The velocities of projectiles producing this type of wound must be greater than those causing penetrating wounds of these tissues. We believe the apparent explosive effect in the abdominal wall wounds is due to this additional imparted energy, which may be in turn transmitted to intra-abdominal structures.

In nine cases of the group, gas and liquid containing viscera were injured. This type of viscus may be particularly prone to injury from such indirect trauma due to the transmission of the force by the contents. The splitting open of the cecum and ascending colon along its anterior longitudinal band in case #3 is offered as an example.

It is a fallacy to assume that no abdominal viscus is involved because the peritoneum has not been found penetrated after laying open the abdominal wall wound. On exploration of the abdominal cavity, in several such cases included in this study a severe injury was seen involving one or more viscera. When there is clinical evidence of intraperitoneal involvement, an exploratory laparotomy is mandatory.

Injuries Of Abdominal Viscera Without Penetration Of Peritoneum. (Associated with Open Wounds (Cont'd).

A brief tabulation of this series of cases follows:-

Case No.	Wound Agent	Wound Type	Wound Location	Organs Involved	Nature of Organ Injury	Surgical Treatment	Comment
1.	No record	Penetrating	LLQ of abdomen	Desc. colon	Incomplete laceration	Laparotomy and suture	None
2.	No record	Perforating	Right flank	Liver	Laceration minor	Laparotomy drainage	None
3.	Shell fragment	Perforating	RUQ	Cecum and asc. colon	Split open along ant. surface	Laparotomy and bowel exteriorized	Also had Compd frac. of femur
4.	Shell fragment	Perforating	RUQ	Liver	Stellate tear right lobe	Laparotomy and drainage	None
5.	Shell fragment	Perforating	Left abdomen	Spleen	Severely lacerated	Laparotomy and splenectomy	None
6.	Shell fragment	Perforating	Left abdomen	Ileum	Contusion	Laparotomy	None
7.	Shell fragment	Penetrating	Right flank	Ascend. colon	Small perf. anterior	Laparotomy and suture	None
8.	No record	Perforating	left chest	Stomach	Hematoma of wall	Thoracotomy and abdominal exploration thru diaphragm	Died shock and pulmonary edema. Extensive lung inj.
9.	Shell fragment	Perforating	Right abdomen	Cecum	Contusion	Laparotomy	None

Injuries Of Abdominal Viscera Without Penetration Of Peritoneum. (Associated with Open Wounds Cont'd).

Case No.	Wound Agent	Wound Type	Wound Location	Organs Involved	Nature of Organ Injury	Surgical Treatment	Comment
10.	Shell fragment	Perforating	Right abdomen	Ascend. colon	Perf. and contused areas.	Lap. and exteriorization ofbowel	None
11.	No record	Perforating	Post-lateral chest, left	Splenic flexure of colon and jejunum	Perf. colon and contusions of jejunum	Lap. and exteriorization of colon	None
12.	Shell fragment	Perforating	Left chest and left abdominal wall	1. liver left lobe. 2. Transverse colon. 3. Jejunum	1. Lacerated 2. Lacerated 3. Lacerated	1. Drained 2. Exteriorized. 3. Sutured	Uneventful course

Injuries Of Abdominal Viscera Without Penetration Of Peritoneum

Due to Blunt Trauma and External Blast

Perforation or rupture of an intra-abdominal viscus is a potential danger in any "blunt" or "blast" injury of the abdomen. This type of injury in the absence of peritoneal penetration was found in 14 instances out of 3154 abdominal and thoraco-abdominal cases studied, an incidence of 0.44%. A group of injuries to the bladder, urethra, and other unogenital structures associated with fractures of the pelvis was not included. They have been covered in a separate study, (see page 378). Although the number of cases here presented is small, the lesions were such that in a majority of the cases death would have occurred in the absence of operative treatment. The viscera most frequently involved either alone or in combinations were: the small intestine, spleen, colon, kidney and mesentery.

Most of these injuries resulted from vehicle accidents (9 of the total 14 cases). There were three cases in which the "blast" from the nearby explosion of an artillery shell was sufficient to seriously injure intra-abdominal viscera.

The patient's history and physical findings were the most helpful elements in deciding the pre-operative diagnosis. In no case was there a skin wound but, on occasions, a subcutaneous hemorrhage indicated the area of greatest trauma. There was usually tenderness, and in 13 cases an absence of peristalsis suggested a "surgical abdomen". Although, in no case was a definitive pre-operative diagnosis made, the signs were such that exploratory laparotomy was performed in all except one of the cases.

Case no. 14, Table I, represents the one in which the abdominal pathology was not suspected initially, and the surgical treatment was limited to that of the chest wall wound. At autopsy the abdominal lesions described were noted.

The mortality rate in this group of injuries was 15% (two deaths). This rate is considerably lower than those found in the literature [1,2] in which mortality rates of 44% and 55% respectively are given for similar types of injuries. We feel that the early and vigorous shock therapy administered to our cases, when indicated, plus early surgical intervention were two factors contributing to this low figure.

A tabulated record of the entire group of cases follows.

REFERENCES

1. Kelly, E. C.; Non-penetrating abdominal trauma. 14 : 163. Surgery, 1943.

2. Ficarra, B. J.: Traumatic perforations of the Small Intestine due to non-penetrating abdominal injuries. 15 : 465. Surgery, 1944.

Injuries of Abdominal Viscera Due to Blunt Trauma and External Blast

Case No.	Wound Agent	Type of Injury	Location of Injury	Viscera Involved	Pathology	Treatment (Surgical)	Postoperative Course
1.	Jeep accident	Contusion	Left flank	Ileum, descending colon	Transected lacerated	Resection exteriorization	Uneventful
2.	Jeep accident	Contusion	Abdominal wall	Ileum	2 lacerations	Sutured	Uneventful
3.	Jeep accident	Contusion	Left upper quadrant	Spleen	torn pedicle	splenectomy	pneumonia (recovered)
4.	Jeep accident	Contusion	Left flank	Kidney 1. mesentery 2.	Pedicle torn 1. Torn 2.	1. Nephrectomy 2. Sutured	Uneventful
5.	Shell explosion	blast, contusion	Abdominal wall	Spleen	Fractured	Splenectomy	Wound dehiscence 7 PO day. 2° clos. recovered.
6.	Half track	Crushing	Abdominal wall	Descending colon	Serosal tears	Sutured	Uneventful
7.	Command car	Crushing	Abdominal wall	Jejunum	Transection	Sutured	Uneventful
8.	Jeep	Contusion	right groin	Ileum	Laceration	Sutured	Uneventful
9.	Wagon	Crushing	Abdominal Wall	Ileum	Laceration	Sutured	Uneventful
10.	Auto	Blunt Injury	Abdomen	1. Jejunum 2. Mesentery 3. transverse colon.	1. transected 2. Torn 3. serosal tears	1. resection 2. Sutured 3. sutured	died 13 PO day peritonitis pneumonia

Injuries of Abdominal Viscera Due to Blunt Trauma and External Blast cont'd.

Case No.	Wound Agent	Type of Injury	Location of Injury	Viscera Involved	Pathology	Treatment (Surgical)	Postoperative Course
11.	Shell explosion	Blast	Abdomen	Spleen	Fractured	Splenectomy	Uneventful
12.	Fall 12 feet	Blunt Injury	Left flank	1. spleen left 2. Kidney	1. fractured 2. pedicle torn	1. splenectomy 2. nephrectomy	Uneventful
13.	Bailey Bridge injury	Blunt injury	Left hypochondrium	Tinea coli divided and retracted	Descending colon	Sutured and exteriorized	Uneventful
14.	Shell explosion	Perf. wd of chest wall blast injury to abdomen	Left chest left abdomen left arm	Lung Stomach Small bowel Colon	Hematoma and pneumonitis (blast) Subserosal hemorrhage Mucosal tears Mucosal hemorrhages	Chest wall debridement No surgery of abdomen. Pathology found at autopsy.	Died 17th P.O. day of acute circ. collapse and intestinal abst. Sec. to the blast injuries.

Abdominal Injuries Of Special Types

Wounds Penetrating Peritoneal Cavity Without Visceral Injury.

A comprehensive review of thoraco-abdominal and abdominal wound cases operated upon in forward hospitals by surgeons of this Group disclosed a series of patients in whom no significant damage to intraperitoneal viscera was sustained despite penetration of the peritoneal cavity by a missile. Only 41 such cases were found, representing 1.3% of the total group of 3154 cases reviewed for the 1944-45 period.

We did not include in this list 3 cases of omental injury. In one of these, a segment of omentum had herniated through a perforation in the diaphragm, becoming gangrenous, and was resected. The other two patients sustained only rents in the omentum which were sutured. The post-operative course was uneventful. Wounds of the mesenteries have been covered in separate studies. (See "Abdominal Vascular Injuries" and "War Wounds of the Small Intestine", pages 238 and 385).

The 41 cases represented 24 thoraco-abdominal (58.5%) and 17 abdominal wounds, figures which differ considerably from the relative proportions of such wounds in the entire series (thoraco-abdominal wounds 26.6%). The right diaphragm was wounded 13 times, the left 11 times.

The wounding agent was listed as high explosive shell fragment in 33 cases (80%) and gunshot in eight (20%). Twenty-nine (70%) of the external wounds were penetrating in type. Eleven (30%) were perforating. An analysis of the locations and nature of the wounds involving the peritoneum proved interesting. In the group of 24 diaphragmatic wounds the missile had entered from the thoracic side 23 times. The diaphragm had sustained a double perforation in seven cases with the missile either lodging in the lung or passing out through the chest wall. In eleven cases the perforation was single; two of these were produced by sharp rib fragments. The missile had lodged in the diaphragm in the remaining five cases producing only a small opening in the peritoneum. A study of the group of 17 abdominal wounds revealed no case in which the missile had passed freely across or through the general peritoneal cavity in a major diameter. The peritoneal wounds in these cases were caused by missiles which had either perforated across small angles, lacerated the peritoneum in burrowing through extraperitoneal tissues, or had so exhausted their momentum as to fall harmlessly into the peritoneal cavity.

Variable degrees of hemoperitoneum were found in most of the 41 cases, the source being extra-peritoneal. It was this blood, sometimes over a liter in amount, which produced the clinical symptoms and signs of intra-abdominal pathology in these cases.

Surgical approaches to the abdominal explorations done in each case conformed fairly closely to the type of wound. All the abdominal wound cases were explored through laparotomy incisions. In the 24 thoraco-abdominal wounds 20 explorations were done through the chest

Abdominal Injuries Of Special Types. (Wounds Penetrating Peritoneal Cavity Without Visceral Injury cont'd).

and diaphragm only; two through laparotomy only, and two through both incisions. The wound of the diaphragm was sutured in every case.

Only two deaths occurred in the entire series. One patient who had sustained an evisceration of one and one-half feet of ileum through an abdominal wall wound died unexpectedly three days after operation, of a massive pulmonary embolism. The source of the embolus was not stated. The other patient had sustained a severe retro-peritoneal wound with severence of the left common iliac vessels. He died 10 days after operation from pneumonia, peritonitis, and retro-peritoneal cellulitis.

We feel that one observation of special interest was made during this study, i.e., no instance was found in which the missile had passed across the general abdominal cavity. Since the total group studied represents a very large series (3154 cases) in which the policy has been to explore all cases presenting evidence or suspicion of peritoneal penetration, it would seem that instances of missiles passing through the abdomen without causing harm, must be rare indeed. Clinical recovery may ensue in such cases without operation, because certain wounds of the gastro-intestinal tract tend to seal themselves. The risks involved in non-operative handling of such cases, however, are not justified in view of excellent present day surgical facilities in forward hospitals.

FORWARD SURGERY
OF THE
SEVERELY WOUNDED

VOLUME II

A History of the Activities

of the

2nd Auxiliary Surgical Group

1942 - 1945

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VOLUME II

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THORACIC WOUNDS

THORACIC WOUNDS

Part I

The Initial Surgery of 2267 Penetrating and Perforating Injuries of the Thorax Including 903 Thoraco-abdominal Wounds

Page

THE INITIAL SURGERY OF 2267 PENETRATING AND PERFORATING INJURIES OF THE THORAX INCLUDING 903 THORACO-ABDOMINAL WOUNDS

A Summary of Cases Treated by the 2nd Auxiliary Surgical Group from November 1942 to May 1945.

In war wounds of the chest treated during the North African and European Campaigns of World War II there has been a great reduction in mortality rates as compared with those of the last World War. Though it is now recognized that the treatment of war wounds of the abdomen has been revolutionized during World War II [1], in reality a similar advance has been made in the treatment of wounds of the chest. Both have been achieved by the same means, namely, the application of the physiological approach to those injuries and the use of principles previously developed and applied in civilian life during the period between the wars.

The principles of treatment of thoracic war wounds have not been radical departures from previously conceived principles and methods. The advances are due to the greater appreciation and application of the physiology of the cardio-respiratory system together with skillful anesthetists and adequate anesthestic apparatus. Even though civilian experience in trauma of the thorax was meager up to the onset of the present war, the great developments in non-traumatic surgery formed a solid base on which the concepts of treatment, outlined in this report, were built.

The report here presented is a summary of the work done by the surgical teams of the 2nd Auxiliary Surgical Group during the campaigns in Tunisia, Sicily, Italy, Southern France, the Rhineland and Central Europe. The work of 27 general surgical teams and five thoracic surgical teams is presented. All cases with penetrating or perforating wounds of the pleural cavity are included. Injuries to the thoracic cage without pleural penetration are not included even though we realize that many cause intrapleural damage without pleural penetration.

This report is concerned only with the INITIAL surgery of the wounded, the term "initial" being used in the sense in which it was set forth by the Theater Surgical Consultant [2]. All cases were operated upon either in Field Hospitals or in forward Evacuation Hospitals and in each instance comprised the first surgical treatment afforded the casualty except for such preliminary measures as may have been applied in the Battalion Aid Station or in the Clearing Station. A small group, during the early phase in Tunisia and during first day or two of some of the five amphibious landings, were operated upon in Clearing Stations.

The Initial Surgery of The Thorax And Thoraco-Abdominal Wounds.

A detailed description[3] of the use of Field Hospitals as first priority surgical installations in the forward area and the employment therein of auxiliary surgical teams will be found in the section on Operations, page ~~357~~. 955 - 900

TRANSPORTABILITY OF THORACIC CASUALTIES

The Field Hospital platoon has equipment and personnel (even with Auxiliary Surgical Group teams) for handling only a limited number of first-priority surgical patients. Whenever the patient load gets over 50 first priority cases it is impossible for the small staff of nurses and enlisted men to care adequately for all the patients. It is therefore advisable that the number of patients operated on in the Field Hospitals be kept to a minimum. It is not feasible for these reasons to attempt to operate on all chest casualties at this most forward surgical installation. The emphasis in the Field Hospital should be on abdominal, thoraco-abdominal and severe extremity injuries where time lag is a more important factor. Also, it is well recognized that these first-priority patients do not withstand the necessary time and discomforts incident to further evacuation. In contrast, thoracic injuries that are not in shock or have been restored to cardiorespiratory balance withstand evacuation very well indeed [4]. If it were possible to treat all casualties of any degree or any region at this early stage it would be commendable, but this is not practical and the load of caring for the large majority of cases must be borne by the Evacuation Hospitals. It is these hospitals that should treat all but the most severe thoracic casualties. The main function of the Field Hospital insofar as the majority of chest lesions is concerned is to act as a triage center to which the medical officers of the Clearing Station can send any case about which they are in doubt either as to his transportability or the presence of a thoraco-abdominal lesion. The latter is not always an easy decision to make. If there is reasonable suspicion that such may exist, especially if on the left side, he should be held in the Field Hospital for surgical exploration.

In the early campaigns it was not always appreciated by many how well thoracic cases could be transported if care was taken to assure their being in the best possible state before being evacuated. Such evacuation has now become a standard practice and has relieved the load on the Field Hospitals. Shefts[4] working in an Evacuation Hospital studied this problem on patients evacuated to him. In his series of 113 cases there was not one death that could in any way be attributed to the patients' evacuation. Over 50% of the pure thoracic cases admitted to the Field Hospital during the later campaigns were evacuated to the Evacuation Hospitals.

without surgery being done. Frequently simple measures such as thoracentesis or intercostal nerve block were employed in the preoperative tentto effect cardiorespiratory stabilization so that they became transportable cases. Thus, cases treated in Field Hospitals (when used as first-priority surgical installations) were composed of abdominal, and thoraco-abdominal injuries, traumatic amputations, severe vascular injuries or thoracic cases that could not be brought into cardiorespiratory balance by other than surgical therapy. Most thoracic cases without exceptionally large chest wall defects or thoraco-abdominal injuries, can be stabilized and safely evacuated.

MATERIAL

During the period covered by this report surgical teams of the 2nd Auxiliary Surgical Group operated on approximately 22,000 cases. Included in this group are 2,629 abdominal injuries, 903 thoraco-abdominal lesions and 1,364 penetrating or perforating injuries of the pleural cavity.

Of the 1,364 thoracic injuries, 135 ended fatally in the hospitals in which they were operated. This is a mortality rate of 9.89%. If all save U.S. troops are eliminated, the mortality for American soldiers is 9.21%.

The chest was the major wound in 1,112 of these patients while 137 has associated wounds that were of greater severity than their thoracic lesions. The mortality for the 1,112 was 6.29% and the mortality for the 137 was 33.58%.

Two hundred and forty-seven of the 903 thoraco-abdominal lesions ended fatally, a mortality rate of 27.35%.

In order to have a basis of comparison of the early and late campaigns, the cases have been divided arbitrarily into two groups using 1 May 1944 as the dividing line. By this time, the principles of management of thoracic war wounds had become much more widely disseminated and a somewhat better defined policy had been laid down. The effects of this wider knowledge should therefore become evident. Also, this date coincides quite closely with the period at which adequate amounts of blood became available through the blood bank. Penicillin which previously had been reserved for

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds. (Material cont'd).

special types of cases was made available for all, and it can be assumed that such therapy was used in practically all major thoracic injuries after that date. Cases treated by the thoracic surgical teams have likewise been summarized separately from the general surgical teams to determine if there was any difference between the two groups and if there has been corresponding improvement in the two series.

It is fully realized that so many imponderables enter into any study of cases based on records filled out by medical officers under field conditions that the statistical analysis thereof may be most misleading. Although the records of this group of patients are quite good, comparatively, the data are by no means sufficiently complete to warrant derivation of conclusions on the basis of the figures alone. It is our intention therefore, not to rely solely on the figures. The discussion and conclusions are presented as the combined opinions of the Group, that have been developed on the basis of a two and one-half years' personal experience. Even though follow-up studies are available on a sizeable percentage of the cases, it is not complete to a degree compatible with accuracy and, therefore, this study is limited to the condition of the patients at the time of discharge from the hospital where first treated. Mortality figures as well as the incidence of complications during this phase are reasonably complete and, therefore, of statistical significance. Tables have been compiled from those case records which have included the necessary data. They may be found in the statistical appendix.

DIAGNOSIS

Rational therapy can be based only on accurate diagnosis. This is true in thoracic wounds to a greater degree than for certain other regions of the body. In many, such as the abdomeh, it is known that if there is presumptive evidence of peritoneal penetration a laparotomy is mandatory. One may also explore a severe wound of an extremity before deciding whether or not an amputation should be done. Such procedures are not applicable in thoracic injuries as it is important that intra-thoracic manipulations be avoided in the forward areas except for specific indications. The type of operative treatment (that is, either debridement or thoracotomy) depends upon the surgeon's examination and decision as to the probable damage. Two questions are posed by every thoracic casualty seen in the Field Hospital. The first are whether or not the injury is such that the

patient should be operated on in the Field Hospital or evacuated? The second is what type of operation should be performed? In the forward Evacuation Hospital only the second problem has to be considered.

There are three main points of interest to the examiner of a thoracic casualty: First, the course of the missile and the probable damage done by it directly; secondly, an estimation of the "blast" effect produced by the missile; thirdly, the detection of signs of completely or partially obstructed airway. The general appearance of the patient should be the first thing to which the examiner directs his attention. Even though it may be unscientific, there are certain patients that just "don't look good". It is one of the most important observations that one can make. In war surgery it is to be relied upon to a greater extent than the blood pressure, pulse or other recordable findings. This first over-all appraisal should take in any associated wounds, the patient's general condition, and various other factors that do not admit an accurate description. The expression on the soldier's face, his color, type and character of respirations, the "look in his eyes", and whether or not he is alert are all factors that the experienced examiner takes in at first glance. After this first survey is made one is ready to proceed with a more orderly and complete examination.

HISTORY: The term history has a connotation that is not applicable in war surgery. There are many things, however, about which more information should be obtained than will be found on the Emergency Medical Tag. As is true of civilian practice, it is wise to ask the patient what is bothering him the most. War wounds are frequently multiple and often the chest may not be the patient's main complaint even though it is his most serious wound. If attention is first directed to the patient's chief complaint he is more apt to feel that the surgeon is really interested in helping him and thus confidence is established. Specific things that should be asked about include the following: Pain, its type, location and relationship to respiration; difficulty in breathing and whether or not the difficulty is increasing or decreasing; has he coughed up blood and if so how much; has he felt nauseated or has he vomited; when did he eat last and what is the relationship of this to the time of wounding (frequently undigested food remains in the stomach many hours under the stress and strain of combat conditions); was he unconcious and if so for how long; has he noted any sucking of the wound; does the time he was injured agree with that noted on the record; what type of missile does he believe struck him and if it

was an explosive shell how far from him was it when it exploded; and what position was he in when hit. All these questions can be asked in a few moments and will often yield a surprising amount of additional information.

Pain of some degree is the rule in thoracic wounds although it frequently will have been dulled by morphine before the patient reached the Field Hospital. As the pain is from the chest wall its presence or absence has no bearing on the question of pleural penetration. As it is accompanied by splinting of the hemithorax it favors hypo-ventilation and should be relieved, (as discussed below), when of such severity as to produce diminished respiratory excursions. The patient's greatest hazard in the pre-operative period is anoxia and all necessary measures should be taken to combat it.

Difficulty in breathing may either be due to actual "shortness of breath" or the more common complaint of being "unable to take a good breath". The latter is due to the associated pain and can be relieved by injecting the intercostal nerves. "Shortness of breath" implies deficient oxygenation of the blood which in the absence of severe blood loss, is usually attributable to decreased functioning pulmonary parenchyma. Many factors contribute to this, the most prominent of which are hemothorax, pneumothorax and hemorrhagic infiltrations of the lung. If a history of increasing dyspnea is obtained it suggests increasing pressure on the lung by blood or air and its removal, without delay, is indicated.

Hemoptysis of some degree is expected in almost all cases of penetrating lesions of the thorax. It is likewise common in severe thoracic wall lesions or blast injuries in which the lung is contused. It is a warning sign that damage has been done. The amount of blood coughed up varies with the particular lesion but has some bearing on its severity. Those with large amounts are more apt to have some postoperative difficulties unless care is taken to maintain an open airway. When the patient is unable to raise the material by himself he must be assisted, otherwise the air exchange is hindered and oxygenation of the blood in the pulmonary capillaries is inhibited.

Nausea and vomiting are not commonly seen in the casualty with only a thoracic wound. If present, they suggest a possible thoraco-abdominal lesion.

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds. (History cont'd.)

A short period of unconciousness is not infrequent when injury has been caused by a high-explosive shell. Longer periods, especially if preceded by conciousness, are apt to be due to cerebral anoxia and are therefore of utmost importance, both in regard to the severity of the wound and from a prognostic standpoint. Unconciousness of more than momentary duration means that there is either cerebral concussion, severe blood loss, or cerebral damage from prolonged anoxia. Maniacal manifestations, frequently a sign of severe anoxia, may likewise be present and this oxygen want must be combatted vigorously.

A history of "sucking" or exchange of air through the wound is presumptive evidence that the missile has penetrated the pleura. Rarely, such a noise may be noted in extensive soft tissue lesions without pleural involvement especially if there are multiple rib fractures giving a flaccid chest wall. The absence of sucking has no bearing on the course of the missile nor the damage it may have produced.

The position the patient was in when injured, the type of missile and how close to him it exploded, if an explosive shell, are all of great significance when arriving at a final decision as to the probable intra-thoracic lesion. Only by knowing these factors can one visualize the probable injury. It is absolutely imperative that the surgeon plot the course of the missile to his best ability in order to appraise most accurately the damage to the thoracic organs and tissues involved.

PHYSICAL: Hemopneumothorax is the most common physical finding in thoracic casualties. Any penetrating or perforating wound of more than slight severity must result in at least a small amount of blood or air entering the pleural cavity. Small amounts are of little significance, but when either blood or air restricts and prevents complete lung expansion, and thus adequate oxygenation, they become symptomatic and means of correction are indicated. A discussion of the physical signs of hemo- or pneumothorax is not necessary. It should be emphasized however, that the signs may be most misleading as to the size of the pleural collection and that the severity of the symptoms may be little related to the amounts of fluid or air detected on physical examination. Certain things are always to be looked for. Most important is the general appearance of the patient including his color. If cyanosis of any degree is detected it is a warning sign that vigorous measures are indicated to re-adjust the

cardiorespiratory mechanism to a more nearly normal state. If other signs of cerebral anoxia are present such as unconciousness or maniacal manifestations, the urgency for adequate therapy is greater. Every effort should be put forth to prevent, combat, or alleviate decreased oxygenation. It is to be remembered that cyanosis is a sign of comparatively advanced anoxia and measures to decrease anoxia such as thoracentesis and the administration of oxygen are better instituted before the appearance of cyanosis. In cases with severe blood loss, cyanosis may not be detectable due to the lowered hemoglobin content of the blood.

The type and character of respirations are of particular importance. Those patients with badly contused lungs either from a direct injury or blast often exhibit the signs of "wet lung" as discussed below. The rapid, rattling respirations with frequent, ineffectual coughs indicate that difficulty is being encountered in maintaining a clear air-way.

Certain gross physical findings seem to be of more importance in the examination of thoracic war casualties than are the more refined methods applicable in other situations. For example, checking the position of the trachea in the suprasternal notch or the apex impulse of the heart will give as much or more evidence of a clinically significant hemopneumothorax than very careful, time-consuming percussion and auscultation. The latter methods are not to be disregarded but a busy, noisy, preoperative ward is often times a difficult place in which to carry out a meticulous examination. Minor deviations from normal are not of particular significance and it is the patient as a whole and his gross abnormalities upon which attention should be focused.

After the examiner has talked with the patient and secured as much of the information as possible that was discussed above, and has made a quick general survey of the patient and noted any accompanying wounds of clinical importance, he is ready to examine the wound or wounds of the thorax. A decision as to the type of surgical therapy that will be indicated is based largely on the damage assumed to be done from the information so far obtained plus lining up the wound of entrance and present location of the foreign body as found on roentgenography, or projecting the course of the missile between the wounds of entrance and exit in the case of perforating wounds. Multiple inspections of the wounds by various personnel are to be avoided as they only lead to added risk of infection and, in the case of sucking wounds, further admission of air into the pleural cavity. Wounds that are adequately dressed before admission to the Field Hospital need not to be disturbed until they can be

seen by both the shock officer and the surgeon at the same time. The entire thorax, back, lumbar area and abdomen must be examined in every case otherwise a small wound of entrance may be overlooked to the later consternation of the surgeon.

Fortunately, most foreign objects travel in a straight line from entrance to exit, or entrance to lodgement. The voluminous literature on the erratic course of missiles within the body have tended to over-emphasize the exceptional case that takes a bizarre course due to striking a rib or other bony structure. The explanation of most peculiar foreign body tracks is found by questioning the patient regarding the position he was in when injured. When the patient with a foreign body within the thorax that shows no wound of entrance other than the one over the deltoid tubercle of the arm tells the examiner that he was lying on the ground with his arm extended along side of his head, the course of the missile is no longer mysterious.

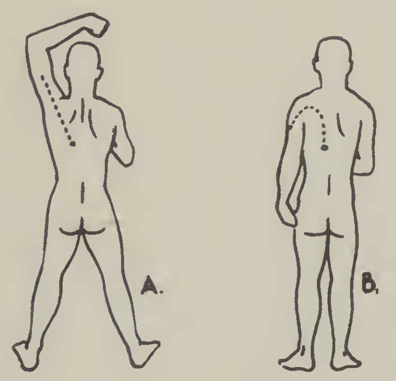

Figure 56 - Illustration of the apparent bizarre course of an intrathoracic missile, in a patient whose only wound is in the upper part of the arm.

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds. (Physical cont'd).

As is discussed below, the most frequent single indication for surgical treatment of the thoracic casualty in the forward area is a thoraco-abdominal injury either proved or suspected. All thoracic wounds should be inspected with this injury in mind. Again, the most reliable information is obtained by projecting the course of the missile. Those foreign bodies that enter the chest and can be demonstrated to lie clearly within the abdomen by roentgenographic examination or those entering the abdomen and lying clearly in the thorax pose no particular diagnostic problem. Those that either perforate the chest in an area where the diaphragm might be involved or which penetrate the thorax and lodge in the vicinity of the diaphragm give the greatest diagnostic difficulty. Due to the motion of the diaphragm, wounds of the entire lower half of the thorax may penetrate this division between the thorax and abdomen. As can be seen in the accompanying drawings (Figure 57), any lesion below the seventh interspace posteriorly or below the fourth rib anteriorly may injure the diaphragm if the patient is in the expiratory phase of respiration at the time.

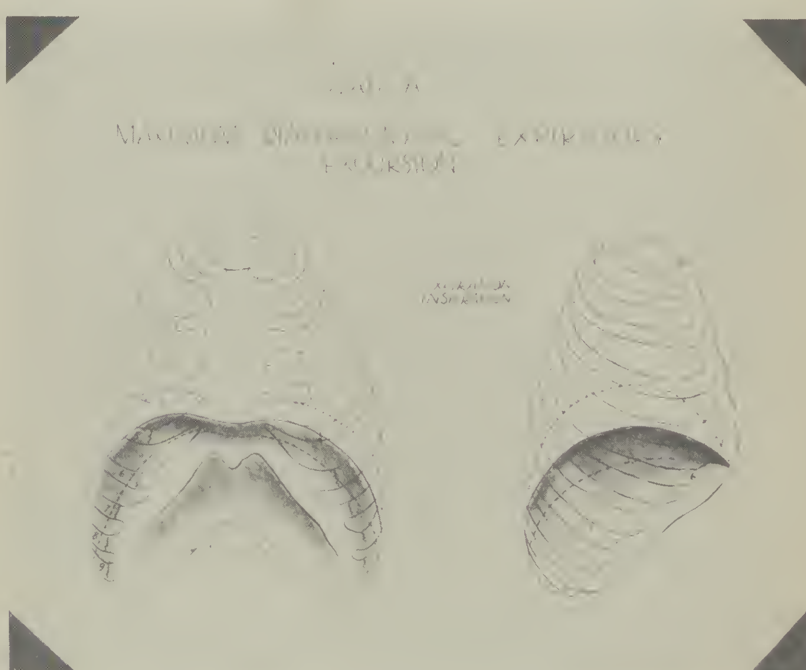

Figure 57 - See text.

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds.
(Physical cont'd).

Likewise, the pleural reflection extends down to the attachments of the diaphragm to the ribs and costal arch so that any lesion at the level of the 12th rib or above posteriorly or involving the costal arch or above anteriorly is a potential thoraco-abdominal lesion.

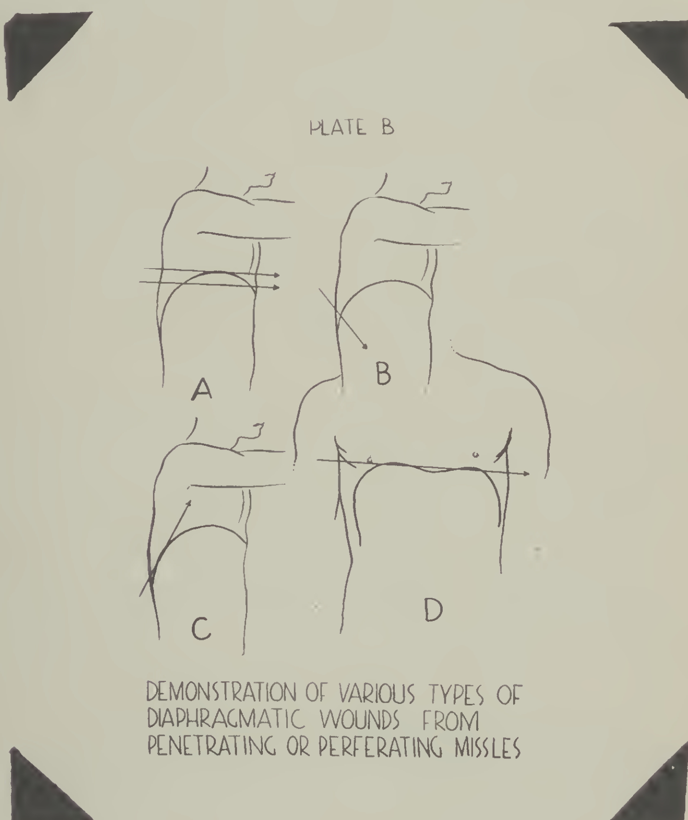

Figure 58 - See text.

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds. (Physical cont'd).

Physical signs of abdominal involvement in the thoraco-abdominal injuries are helpful but not completely reliable. Many thoracic wounds give pain and spasm of the upper abdomen and many abdominal injuries may exhibit a paucity of physical signs, especially if the spleen or liver are the only abdominal organs injured. In those instances of peritoneal contamination from perforation of a viscus, intercostal nerve block of the lower thoracic nerves may be expected to relieve the spasm but not to affect the deep tenderness. Similarly, peristalsis is usually absent in the presence of intestinal perforation. None of these signs is pathognomonic and it is, therefore, necessary that where reasonable doubt exists as to abdominal involvement exploration should be done.

Injuries to the mediastinal structures are the second greatest diagnostic problem. Inasmuch as lesions of the heart and pericardium present a somewhat special situation they will be discussed later. Large hilar blood vessels, trachea or major bronchi, and the esophagus must be considered. Lesions of all these structures are not frequently encountered. Here again the projected course of the missile is the most reliable indication of suspected damage. Signs of continuing intrapleural hemorrhage are to be expected when a large blood vessel has been injured, but this need not be so. Injury to the trachea or major bronchi causes rapid accumulation of air in the pleural cavity and it will be found frequently under increased pressure. In fact, whenever air continues to leak into the pleural cavity it may be assumed that a bronchus or branch bronchus is involved. Associated with this, may be noted varying degrees of mediastinal emphysema which, in our combined experience has never been noted to be under sufficient pressure to obstruct the venous return to the heart and become symptomatic. It is our opinion that most of the symptoms commonly ascribed in the literature to mediastinal emphysema have been due to unrecognized, accompanying pressure pneumothoraces.

There are no pathognomic signs of esophageal injury other than a demonstration of a break in continuity by the swallowing of a radio-opaque material. Diagnosis is usually made on the suspected course of the foreign body. In some instances of esophageal injury pain has been noted in the region of the posterior thorax or radiating down to the lumbar area. Substernal pain on swallowing also has been described. This is probably a result of an inflammatory reaction in the posterior mediastinum, the most frequent cause of which is leakage from the esophagus. If lipiodal is available (it usually is not), the swallowing of one or two cc. with fluoroscopic or roentgenographic examination will give invaluable information. It is to be remembered that widening of the mediastinal silhouette is not necessarily due

to esophageal perforation. This same finding is often due to blood from injury to the vessels at the base of the neck. In many instances where these vessels may be involved, it is wise to explore the neck lesion first as the exact point of involvement may not be determinable preoperatively. Also, certain of these vessels are better approached from the neck than trans-thoracically.

ROENTGENOGRAPHIC EXAMINATION: Rational, intelligent, surgical therapy of thoracic and thoraco-abdominal injuries is not possible without roentgen studies. Every effort should be made to secure the best possible exposures in order to obtain all the information possible. Films should be taken with the patient in the erect position, with the exception of the severely shocked thoraco-abdominal patients, as such films permit much more accurate appraisal of the extent of the process and the organs involved. Projections in at least two planes are necessary. In the occasional instance that demonstrates the foreign body at a considerable distance from what was suspected from examination of the patient, especially if the missile is demonstrated to lie low in the thorax, the possibility of its being free in the pleural cavity is justified. This can sometimes be proved by another film taken with the patient lying down showing a marked shift of the missile.

In those cases showing no foreign body roentgenographically and no wound of exit on examination, one should remember the other possible explanations. The foreign body may have been a large missile of low velocity striking the chest, causing a wound, then falling back to the outside, or, it may be lodged in the abdomen or neck. So frequently are such cases encountered that some hospitals routinely take both abdominal and thoracic views in any case with injury to either region. Although this wastes a few films it eliminates taking patients back for further plates with attendant discomfort to the patient and loss of time.

After the roentgen examination has been completed a review of the case in the lightof all the information, including the course of the foreign body as revealed by fractured ribs, will often clarify the doubtful case.

PREOPERATIVE PREPARATION

The preoperative preparation of the thoracic casualty is not just the administration of the proper amounts of blood and plasma to restore the circulating blood volume to a normal or near normal level. The most important single factor is the correction of

cardiorespiratory imbalance and it is the duty of the shock officer to correct these abnormalities, insofar as possible, before the patient is operated on. The fact that should always be uppermost in the mind of the shock officer is that the aim of the surgical treatment of these casualties is primarily a mechanical readjustment to permit normal respiration, and secondarily, to prevent infection. In abdominal injuries the time interval from wounding to surgery is of prime importance but is of only secondary concern in treating thoracic injuries. The thoracic case frequently dies of mechanical difficulties and attending cardiorespiratory imbalance, but only rarely does he die from infection, while the reverse is true of abdominal casualties. As far as time alone is concerned, it is important only to shorten the interval to the minimum where diminished blood-oxygen supply may produce cerebral damage. Once normal oxygenation of the tissues is established, the time interval from that point to surgery is of much less importance.

Hemopneumothorax, blood loss, pain and an obstructed air-way are the most important shock-producing factors in patients with thoracic wounds. (If a thoraco-abdominal lesion is present, peritoneal and pleural contamination must be added). Varying degrees of one may be present without the other, but the severe injury practically always presents all in combination. The bony thorax imposes very definite limitations on the size of the thoracic cavity. Thus, any space-occupying medium can seriously disrupt the normal function of the heart and lungs. Pneumothorax and hemothorax, both being space-occupying, produce almost identical results. By impeding cardiac return and pulmonary expansion they not only tend to reduce the volume of circulating blood but decrease the degree of oxygen saturation. The response is an increased cardiac and respiratory rate, both almost invariably present in any severe thoracic casualty. The concomitant damage to the thoracic cage produces pain, and to minimize this component, motion is restricted. One therefore finds that these patients present a rapid pulse and rapid but shallow respirations. Deficient tissue oxygenation alone from an obstructed airway, pulmonary compression or contusion, or from a cardiac wound will produce the clinical picture of shock with low or unrecordable blood pressure, and rapid, feeble pulse. The inexperienced are apt to institute rapid blood replacement which may be fatal to an already unbalanced cardiorespiratory system. Intravenous therapy should be withheld in the thoracic casualty until it has been determined that he is suffering from blood loss. The first and primary effort except in those cases with obvious blood loss to the outside should be to ascertain the amount of blood and air that

is in the pleural cavity and to remove it. By aspirating blood or air, or both, from the pleural cavity more will be done toward relieving shock than by starting a blood transfusion.

THORACENTESIS: Much has been written about the use of aspiration of blood and replacement with air in the treatment of hemothorax. It has now been well established that such air replacement is not only unnecessary but is to be avoided. Likewise the fear of aspirating blood from the pleura during the early phase has been dispelled. There is no proof that the relief of intrapleural pressure and resultant lung expansion will start the bleeding anew from the injured pulmonary parenchyma. Even if it did, the shock ward is the proper place to determine this fact as the surgical management may differ widely if the surgeon knows beforehand that he is dealing with a potential injury to a large blood vessel. Bleeding from the pulmonary parenchyma will stop of its own accord in the vast majority of cases, and the relatively small pressure differential that may exist in the pleural space due to a pneumothorax is not efficacious in checking a hemorrhage from one of the systematic vessels. Many more errors are made by not aspirating the chest, than by aspirating it, with the remote possibility of restarting a previously stopped hemorrhage.

There has also been much discussion regarding the amount of blood that should be removed at any one time. No rule can be laid down but it is rarely necessary to stop because of the amount of blood per se. Certainly 1200 cc. to 1500 cc. can be removed with impunity. Should the patient experience discomfort or a feeling of pressure it is wise to stop and repeat the aspiration later if necessary. It is advisable to have blood either available or perhaps already running in the vein during the thoracentesis if the amount involved is found to be unusually large. In the absence of a thoraco-abdominal injury larger hemothoraces, if less than 24 hours old, should be aspirated directly into a sterile Baxter donor bottle in order to save the blood for auto-transfusion.

Air in the pleural cavity poses much the same problem as blood. It should be removed preoperatively for several reasons. First, to increase aeration of the pulmonary parenchyma. Second, to ascertain the presence or absence of a pressure pneumothorax. Third, to determine the presence and approximate size of any broncho-pleural fistulae. Fourth, to obtain apposition of the lung and thoracic wall and thereby decrease the risk of empyema. Although a pressure pneumothorax is a real, life-endangering condition it is not found frequently. In this group of cases it was recorded as

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds. (Thoracentesis cont'd.)

being present in only 11 cases (0.9%). Furthermore, it is doubtful if all the reported cases were true pressure pneumothoraces because, such presupposes an injury that produces a valve-like mechanism which permits an easy ingress but difficult egress of air from the pleural cavity. This is not often found. Air is occasionally found under more than normal or even above the atmospheric pressure, but such may be due to compression of air by intrapleural bleeding or, most frequently, to the irregular, splinting-type respiration, the result of thoracic wall pain. If thoracentesis reveals air under pressure that does not recede to normal levels, it is wise to assume that a pressure pneumothorax is present and provide a safety-valve by introducing a needle or catheter in the pleural space and attaching it to a water seal.

The average thoracic casualty will be most comfortable when lying on his back with his head and thorax slightly elevated. In this position the diaphragms function more efficiently. Thoracic casualties in marked shock, with a systolic blood pressure of 90 mm. Hg. or less, and those that are in coma should have their heads slightly lower than the remainder of their bodies. When there are no signs of anoxia and the patient is conscious, he should be either flat or with his head elevated, whichever is more comfortable and provides the easier respirations. Some have hesitated to carry out thoracentesis frequently enough because they did not wish to disturb the patient by making him change position. This is not necessary as it is possible to remove almost all the fluid from the chest by introducing the needle low in the axilla. The place of preference for aspirating a pneumothorax is the 2nd anterior interspace. Thus, it is seldom necessary to disturb the patient in the least to carry out a chest aspiration. The needles used should be 17 or 18 gauge with short beveled, rather blunt points to prevent damaging the lung. The amount of blood and/or air removed from the chest is a very useful guide to the surgeon in planning the way in which he will repair the injury and help to reestablish normal cardiorespiratory function.

The medical officer caring for the casualties preoperatively is a vital link in successfully treating such patients. There has been too great an inclination in the past to delegate such duties to just anyone who did not have any other pressing duties at the time. This was a costly lesson to learn as it takes wise judgement to treat intelligently the thoracic casualty preoperatively. Whenever possible, such officers should be well-grounded in the basic physiological functions of the heart and lungs. As a rule, a well-trained internist is a better shock officer than a poorly trained surgeon.

RELIEF OF PAIN: It has already been mentioned above that pain is an almost constant accompaniment of any injury to the chest. The painful stimuli originate in the thoracic wall and not in the lung itself. This is the key to proper therapy. It is far better to interrupt these painful stimuli near their origin rather than attempting to mask the symptoms by the use of depressant drugs. The painful impulses can be easily blocked near their origin by a procaine injection of the intercostal nerves supplying that area. This is another procedure that comes within the province of the officer in charge of the preoperative preparation of the patient. Intercostal nerve block is a simple, efficacious procedure that can be accomplished in five or ten minutes and will produce lasting effects far superior to morphine or other depressant drugs. If the painful segment of the thoracic wall is blocked, including two nerves above and two below the site of the injury, lasting effect is the rule rather than the exception. The use of intercostal nerve block has been discussed by many authors [5, 6], and the technic has been amply described [7]. These nerves can be anesthetized at any point central to the lesion. Some find it more convenient to do the injection at the angles of the ribs when the lesion is located anteriorly. Others prefer to do a paravertebral intercostal injection routinely. For the comparatively rare case involving the paravertebral thoracic wall, an injection of the sympathetic trunk above that location will also effectively block most of the pain-carrying fibers. Some confusion has arisen in the recent literature in this regard and it should be emphasized that it is not necessary to block the sympathetic chain in the usual case nor is there any evidence that a sympathetic block produces any result other than that obtained by the simpler intercostal injection. It is probable that any sympathetic block also anesthetizes the contiguous intercostal nerve roots. The technic of paravertebral intercostal nerve block need not be set forth here but suffice it to say that it is a simple procedure technically and without appreciable risk to the patient.

There is seldom any indication for further administration of morphine to the thoracic casualty in the forward zone. One dose of morphine is usually administered by the company-aid man on reaching the casualty. As the standard army morphine syrette contains one-half grain, this is the usual dose. Although this dose is not harmful to many patients, it may be if they are already in severe shock and suffering from relative anoxia. From the thoracic standpoint, at least, it would be far better if the standard syrette contained only one-fourth grain as this dose has practically the same pain-abolishing power as the larger dose and yet is not as depressant. It is not unusual for some patients to be given two or three doses

before they reach the Field Hospital. This is often due to the rush of casualties and insufficient time for the medical officer in the Battalion or Clearing Station to appraise the patient's symptoms and determine whether or not his complaints are due to pain or other causes. Cerebral anoxia is very frequently accompanied by restlessness that at times may be maniacal. It is not difficult to interpret such actions as writhing from pain and thus another syrette of morphine is given. The patient in whom this is most serious is the one who is already in rather marked shock with a lowered blood pressure and poor peripheral circulation. Under such conditions much of the drug may not be absorbed by the blood stream and thus the symptoms are unrelieved, leading to another dose of the drug. By such methods two or three one-quarter or one-half grain doses of morphine may be given without the patient receiving much benefit. When, however, such a casualty reaches the Field Hospital and his circulating blood volume is restored to normal, all this accumulated morphine in the subcutaneous tissues is picked up by the improving circulation and he gets the effects of a huge dose at once with the signs and the symptoms of morphine intoxication. Four percent of our patients received over one-half grain while 0.5% had one grain or more during the preoperative period. This problem has been discussed by Beecher 8, 9, 10.

In discussing morphine administration in the forward area mention should be made of a small group of cases that have been observed by many but for which, at present, there seems to be no definitely proven explanation. There is an occasional thoracic casualty brought into the forward medical installations that presents the typical picture of an overdose of morphine. That is, they have pin-point pupils, a slow respiratory rate and are difficult to arouse. Their records, however, do not record more than one dose of morphine as a rule or perhaps two one-quarter grain doses. Thus, it does not seem that their symptoms were due to the morphine alone. Of course, it is well recognized that the medical record is not always accurate and when these cases were first seen it was attributed by many of us to morphine poisoning and we assumed that the total dosage of morphine as recorded was inaccurate. It is possible that such may still be the cause occasionally, but we believe that such cases are seen too frequently to be attributable to this mistake. Although we have no definite proof of this theory it is our clinical impression that it is another manifestation of relative anoxia. Such patients almost invariably are severely wounded, have suffered from exposure and without oxygen administration show cyanosis. They appear to be more common during the cold winter months when the patient may have

lain out in the cold and wet for several hours, then during the periods of more moderate weather. If morphine is administered, the intravenous route is preferable as the effects are much more predictable thereby.

REPLACEMEMENT THERAPY: The amount of blood and/or plasma that should be given to a thoracic casualty depends mainly upon the amount of blood lost into the pleural cavity, into the lung or to the outside. It is not necessarily dependent upon the degree of shock as measured by the level of the blood pressure as cardiorespiratory imbalance may be more at fault than actual blood loss. Any thoracic casualty will have lost some blood from the circulating blood volume and replacement therapy is a necessary adjunct in restoring the patient to a stable condition. The important thing is not to institute rigorous replacement therapy using large amounts of blood or plasma unless it has first been determined that blood loss is playing a major role, and until measures toward correcting the mechanical abnormalties that are embarrassing the heart and lungs have been at least started. Rapid infusions of intravenous fluids when the heart is already overburdened by a large hemothorax or pneumothorax may so overload the heart as to produce a fatal issue. Likewise, the speed with which blood or plasma is given is important and it need never be given rapidly unless it has been determined that there is continued bleeding from a large vessel or that there has been marked blood loss previously.

Obviously, the only reliable guide to the amount of blood or plasma that should be used is the clinical condition of the patient. The level of the blood pressure is to be used only as a guide to the amount of blood or plasma to be given. It is rarely indicated to use plasma in the preoperative preparation of the thoracic casualty except in those instances where some delay may be encountered in securing and giving blood. Plasma may be needed and have to be given to sustain the patient before admission to the Field Hospital but it should not be needed otherwise in the preoperative preparation. In this regard, it is to be remembered that the time factor is of lesser importance compared with the abdominal wound, or traumatic amputation where gas gangrene may threaten. It is better to proceed slowly with restoration therapy rather than to crowd the deranged cardio-vascular mechanism.

In thoraco-abdominal injuries one has to balance the above factors against the risk of increased time lag, a factor of much importance in any abdominal injury.

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds.
Replacement Therapy cont'd.

It is necessary to operate on the majority of chest casualties either on the side or to turn them on the operating table to expose various wounds. Thus, much time will be saved and difficulties minimized if the infusion given in the preoperative ward is started in one of the veins of the leg. This can usually be accomplished at the ankle without the insertion of a cannula but such should be done if a needle cannot be inserted. Should a cannula be used, the saphenous vein, six inches above the internal malleolus, is the point of preference. A needle in an arm vein so frequently becomes dislodged or the vein obstructed due to the position or turning of the patient on the table that the precaution of starting it in the ankle is very worth while. It not only saves the anesthetist the bother of trying to re-start the intravenous fluids during the operation when the needle becomes dislodged or occluded but provides the patient with added protection as one never knows beforehand when it will become necessary to administer blood rapidly during the operation. Patients with multiple extremity wounds needing prolonged intravenous therapy may not present available avenues of administration. In such instances, use should be made of other routes such as sternal puncture, external jugular veins, and the corpus cavernosum of the penis.

Except for the few patients with continued bleeding from large vessels, it should be possible to restore the thoracic casualty to a comparatively normal balance before proceeding with surgery. In this regard, it is to be remembered that anoxia and excessive CO_2 may result in an elevated blood pressure. Thus, a patient that is admitted with a high normal or elevated blood pressure may at first show a fall with the institution of proper shock therapy. Such readings will not mislead the man experienced in preoperative care but the elevated pressure on admission may give the inexperienced a false sense of security. There is no one reliable guide to the degree of shock in such patients and the clinical impression of the experienced medical officer is a much better guide than any body function that can be measured and recorded numerically.

OXYGEN THERAPY: The greatest hazard to the soldier with a thoracic wound is insufficient oxygenation of the tissues. Thus, any means of increasing the amount of oxygen transported by the blood is indicated. It is a safe rule always to start oxygen on these patients as soon as they are admitted and to continue it until a more detailed appraisal of the patient can be made. Although a mask may be more efficient, it usually has been found that the use of an intra-nasal catheter with oxygen flowing at the rate of at least six to seven liters per minute is the more practical means of

The Initial Surgery of the Thorax and Thoraco-Abdominal Wounds.
(Oxygen Therapy cont'd).

administration. The role of oxygen therapy in the treatment of shock in general has been much debated but there would seem to be no logical argument against its routine use in thoracic casualties [11].

WET LUNG: The pulmonary parenchyma reacts to trauma in much the same way as any other body tissue. That is, either trauma to the thoracic wall or a penetrating or perforating lesion of the lung produces a certain amount of laceration and contusion resulting in extravasation of body fluids into the pulmonary tissues. The amount of such reaction is dependent upon the size and velocity of the missile, and whether or not it strikes any portion of the bony cage, besides many other less important factors. Also the size of the damaged intrapulmonary vessels has a bearing on the amount of extravasated blood. Blast lungs are an example of the amount of pulmonary damage that may result from such a contusing effect even though there is no pleural penetration or even evidence of thoracic cage involvement. There must necessarily to a certain amount of this "blast" effect in any penetrating or perforating lesion quite apart from the damage done by the passage of the foreign body itself. Thus, any thoracic injury, except those of the smallest magnitude, results in some degree of pulmonary contusion. Since the vessel walls are thin and in close approximation to the air sacs, some fluid or blood itself, if the damage is severe enough, must escape into the airway. The pathological findings in pulmonary blast from a pressure wave and in pulmonary contusion from a penetrating or perforating wound are essentially the same. That is, both result in interstitial and intra-alveolar extravasation of blood with edema and rupture of the alveolar walls.

The natural reaction to pain of injury is splinting. Thus, the corresponding hemithorax moves less than the unaffected side with a resultant decrease in the movement of air back and forth in the bronchi. This decreased tidal respiration is probably of more importance than previously recognized as it lessens the amount of material that might be disposed of by evaporation.

It has been noted repeatedly that the findings of "wet lung" are much more common in the cold, wet winter months when many of the casualties have a productive, purulent bronchitis before being wounded.

Some of the severely wounded present an extreme type of "wet lung". Anoxia, tracheal obstruction and increased respiratory effort (all of which may be present in the severely wounded) have been shown by Drinker and Warren [12] to produce pulmonary transudates and exudates. This fluid forms so rapidly and in such amounts that it may be difficult

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(Wet Lung cont'd.)

to keep the airway clean even with a tracheal catheter or by bronchoscopy. Because this condition resembles pulmonary edema seen in other conditions, positive pressure oxygen therapy as used by Barach [13] was employed. In some instances the reduction in rate of formation of this fluid was dramatic. This subject has been discussed by Brewer et al [14].

The above mentioned factors are all operative in the production of more than the normal amount of material in the respiratory passages. Such accumulation of material in the smaller bronchi, the limitation of motion due to pain, the tendency to suppress the desire to cough because of pain, together with the suppression of the cough reflex by morphine, all inhibit proper oxygenation of the blood. The resultant diminished oxygenation is a potent factor in the production and prolongation of shock. Breaking this cycle is an important step in shock therapy.

The problem can be attacked in two ways. One is by relief of pain by intercostal block as mentioned above. This may, in some cases, be all that is necessary. With the relief of pain the patient is no longer hesitant about coughing and by this means removes material from the air passages. Often however, the block alone is insufficient as the patient may be exhausted, or uncooperative for other reasons so as not to cough effectively. In such instances it becomes necessary to remove the blood and excessive tracheo-bronchial material by mechanical means. The simplest method of so doing is the introduction of a catheter into the trachea and major bronchi and aspirating with a suction machine. Such a catheter can easily be introduced through the nose in the manner originally described by Haight [15] and modified by Samson, Brewer and Burbank [16]. In all but the nearly moribund the presence of the catheter in the trachea produces a very powerful desire to cough which cannot be ignored willfully by the patient. He is thus forced to cough even though he may try to prevent it. It is this combination of induced coughing together with the mechanical removal of the material through suction on the catheter that clears the airway. The results of such therapy are often dramatic and will change the cyanotic, comatose patient with a very wet, rattling type of respiration to an alert patient with good color in a matter of a few minutes. One such aspiration may improve the patient sufficiently so that he will cooperate and cough effectively thereafter. If not, the aspiration must be repeated. In those instances where the patient is comatose or unresponsive, even after aspiration, it is often convenient to leave the intratracheal catheter in place using it for aspiration of fluid material when necessary and for administration of oxygen in the interval between. (Caution is to be exercised to assure the correct position

of the catheter. Inadvertent introduction into the esophagus can produce gastric dilation of serious proportions). Such a catheter is surprisingly well tolerated for a period of hours by the comatose patient. A detailed discussion of this problem of "wet lung" will be found in the literature by Samson, Burford, Brewer and Burbank [14, 17, 18].

GASTRIC DILATATION: Many patients even without abdominal injury show marked degrees of gastric dilatation sufficient to cause respiratory embarassment. It is especially true of thoracic cases. This finding has recently been discussed by Beech and Wolff [19]. A Levin tube should be inserted into the stomach during the preoperative period to relieve any dilatation of the stomach and to help prevent vomiting during the induction of anesthesia. In thoraco-abdominal injuries drainage of the stomach preoperatively is mandatory.

ANESTHESIA

The anesthetist is probably the most important member of the operative team caring for thoracic casualties during surgery. As has been pointed out elsewhere [20] "a well-qualified anesthetist can support an inexperienced surgeon better than a brillant surgeon can maintain an inexpert anesthetist". Whenever possible, the anesthetist should be a physician as he has far greater responsibilities than just keeping the patient in the proper plane of anesthesia. He should be able to manage the shock therapy during the operative period and must maintain a clear airway at all times. Ideally he should also be qualified to carry out bronchoscopic aspiration.

There is a place for local anesthesia in the treatment of thoracic wounds but it is quite limited in the forward zone. Not only do these patients usually have a sufficiently severe wound to require general anesthesia but it is the rule rather than the exception to have associated injuries requiring operation so that local anesthesia becomes impractical. Paravertebral nerve block plus local infiltration is sufficient, as far as pain relief is concerned, to carry out practically any thoracic procedure. But the necessity of positive pressure to inflate the lungs and the need for anesthesia for other accompanying wounds has resulted in a very small incidence of local anesthesia for thoracic injuries in the forward area. On the average 14.8% of the anesthesias used in this Group before May 1944 and 7.7% after 1 May 1944 were procaine. The higher incidence in the first period was due to the treatment of a greater number of the less severely wounded thoracic cases in Field Hospitals instead of sending them to the Evacuation Hospitals as was the policy later on.

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The same can be said of pentothal anesthesia. It can be used in the less severe cases and in any where the pleural defect is small or the pleural cavity is not to be exposed. The uncertainty of determining precisely before operation just what will be found at operation has limited very markedly the application of this anesthetic agent. It is a sage rule to always use endotracheal anesthesia in any instance where it is contemplated either to expose the pleural defect or do anything more than a simple debridement of the thoracic wall. A study of our figures reveals that endotracheal anesthesia was used in 48.5% of the cases prior to May 1944. During the one year period from May 1944 to May 1945 the percentage of endotracheal anesthesia was found to be 80.9%. This again reflects the change in evacuation policy as well as the realization by the surgical teams that it is better to err on the side of too extensive preparation rather than to start an operation under pentothal or procaine, only to find that it is desired to carry out a more extensive precedure, necessitating a change of anesthestic agents.

Anesthetizing a severely wounded thoracic casualty is a far cry from the routine anesthesia given in civilian practice. These men have not been as well prepared as is the rule in civilian life. They have had recent damage to their respiratory systems and often have considerable oozing of blood into the respiratory passages. Besides these factors, their shock may not have been completely corrected, and treatment of it must be continued during the period of the operation. All these factors impose an added burden on the anesthetist as he must handle them all, while keeping the patient in the proper plane of anesthesia. Maintenance of a clear airway is of prime importance. The problem of wet lung has been briefly discussed above and there can be no doubt but that the soldier with a chest wound is apt to have a marked amount of material composed of blood and mucus in his respiratory passages. If this material is allowed to accumulate it prevents ingress of air and interferes with oxygenation of the blood, which presents a real hazard to the patient. It is a prime duty of the anesthetist to keep the material out of the air passages and to provide optimum conditions for oxygenation. A further threat of this excessive material in the bronchi and trachea is the possibility of its being disseminated to the opposite lung as it is usually necessary to operate these patients lying on their better side. This provides the best possible condition for the drainage of blood and mucus from the injured lung to the uninjured side with resultant atelectasis. Periodic aspiration of the trachea and bronchi with a long, small caliber catheter introduced through the endotracheal tube is usually sufficient to cope with this hazard. It may be necessary, because of demonstrated inadequate exchange,

to perform a bronchoscopy during operation. Though this is rarely indicated the anesthetist should be able to carry out the procedure when necessary. Likewise, the cleansing of the air passages at the completion of the operation is his responsibility and bronchoscopy is often indicated.

It is advantageous to have the lung expanded periodically during the operation by the anesthetist in order to facilitate re-expansion at the termination of the operation. Such expansion should likewise be done during the operation at any time when there is any indication that the patient may not be well oxygenated.

It can be readily appreciated in view of the foregoing that the anesthetist carries a large part of the responsibility in treating these severely wounded men. The more competent the anesthetist the less the burden on the surgeon. With a well-qualified anesthetist at the head of the table the surgeon can give his undivided attention to the operative procedure itself.

BASIC OPERATIVE CONSIDERATIONS

As stated previously in most wounds of the thorax, without abdominal involvement, cardiorespiratory physiology will be restored in part or entirely, by resuscitative means. Major surgery is necessary in a small number to restore cardiorespiratory balance but in the great majority, including thoraco-abdominal injuries, it is employed to prevent infection. It is only to the degree that the surgeon is able by surgical means to restore the patient to a normal cardiorespiratory balance that he will obtain dramatic improvement in the condition of the patient with an uncomplicated thoracic injury. It is not to be implied that thoracic patients do not die of infection, but it is not the usual cause of early postoperative deaths. These early deaths are due to disturbed physiology while the deaths from infection are practically all limited to the late phase from weeks to months later. <u>Thus the surgeon's primary interest at operation is the restoration of a functioning lung which is fully expanded against an intact or restored thoracic wall.</u> Prevention of infection is important but only secondary. Respiration is dependent upon lung expansion and an intact thoracic cage, and it is toward the attainment of these two objectives that the surgeon's attention is directed.

The above factors plus those of peritoneal contamination are of importance in the thoraco-abdominal cases. Here, resuscitation cannot be complete without surgical repair of the intraperitoneal

damage. Operative interference is indicated as soon as cardiorespiratory stability will permit.

It is not necessary that the surgeon be too concerned with what may be the later complications, in the case with only thoracic involvement. His prime concern is the saving of life and other less pressing factors may be relegated to the thoracic center in the base. With some regard however, for what may be the late complications the forward surgeon can go a long way in relieving the load on the base center and lessening the morbidity. That is, a foreign body in the lung should be removed if the surgeon has the lung exposed for some other reason, yet an intra-pulmonary foreign body is seldom an indication for a thoracotomy in the forward area. On the other hand it is known that large hemothoraces which are allowed to clot and are not removed often result in a marked reduction in pulmonary function due to a fibrin deposit that encases the lung. When this is of sufficient degree it may have to be evacuated at the base. If the surgeon who carries out the initial surgery removes this blood there will be no further pulmonary crippling necessitating a second operation. Thus, it can be understood that the surgeon doing the initial surgery is to be primarily concerned with saving the patient's life yet, by exercising judgement and taking advantage of the opportunities presented, he may be able to prevent increased morbidity, including that due to infection, and secondary operative procedures.

PENETRATING OR PERFORATING WOUNDS NOT DEMANDING THORACOTOMY

A recent MTOUSA directive [21] clearly states what conditions in themselves are not indications for early thoracotomy in the forward areas, either by extension of the wound or by separate incision: "(a) Foreign bodies, i.e., metallic fragments, or rib fragments in the lung, or small fragments that may be in the pleural space. (b) Hemothorax (evacuation of blood, from the pleural cavity by suction at the time of chest wall debridement is not considered a thoracotomy). (c) Lacerated or contused lung unless there is definite evidence of continuing hemorrhage". The surgeon doing forward thoracic surgery must always remember that his main objective is the preservation of life and that he is not to concern himself primarily with anything else, It has been conclusively shown [22, 23, 24], that over-zealous surgical interference in the early phase results in an increased morbidity and number of complications. It is further suggested by the figures presented in the statistical appendix attached hereto that the mortality is the lowest when the forward surgeon confines his major intrathoracic operations to the definite indications

presented below. It should be emphasized that the performance of an unwarranted thoracotomy puts an added burden on an already damaged cardiorespiratory system. By so doing, the forward surgeon unwittingly may be administering the coup de grace.

For the purpose of discussion it is necessary to divide these penetrating and perforating wounds into two groups, the small and the large, as the surgical treatment of them differs. The larger ones, by which we mean any that produce a pleural defect six cm. or more or which destroys three or more ribs and intervening structures are termed traumatic thoracotomies. The latter term is employed because when the wound is debrided one is presented with a pleural defect of such extent that any necessary intrathoracic procedure may be carried out. THE OPERATION THEREBY BECOMES A THORACOTOMY, BECAUSE OF THE SIZE OF THE DEFECT CAUSED BY THE MISSILE!

The surgical treatment of the first group, the small penetrating or perforating lesions, resolves itself into treatment of the wound, removal of blood and/or air from the pleural space, re-expansion of the lung and securing an air-tight closure. This group (pleural defect after debridement of less than six cm.) does not present any great difficulty in thoracic wall closure. Most often it is not possible to close the pleura itself, but we feel it is unnecessary unless easily accomplished. This means however, that there is an opening between the thoracic wall structures and the pleural cavity. Thus, any infection occurring in the soft tissues of the thoracic wall can easily extend into the pleura producing an empyema. For that reason we advocate a radical debridement of the missile track down to the intercostal structures. These need not be resected except in instances of marked damage, since by so doing the defect is enlarged. Wound excision of the thoracic wall would be a more appropiate name for our method of treatment. In this group of smaller lesions, closure of the thoracic wall structures is not difficult, and one should feel free to excise as widely as necessary.

Whether or not a catheter is inserted into the pleural cavity for pleural lavage with normal saline depends upon the amount of blood and clots present. In many instances it is possible to so remove not only the liquid blood but clots as well. Thus, one of the main objectives of early therapy - rapid expansion of the lung - may be advanced by this procedure. Diligent aspiration of the chest with a needle is just as effective in the removal of fluid blood and has been used in the majority of cases in this report.

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It is advisable to leave the skin open as it can be closed a few days later at the base and there is little delay in securing complete wound healing. Primary suture could be carried out safely in many of the cases but the complications in the occasional case more than offset the gain that would be obtained. Following the operative procedure it is our practice to carry out an intercostal nerve block going at least two nerves above and two below the site of injury in order to insure a painless wound that allows the patient deep respiratory movements and coughing without pain. Such prophylaxis prevents many postoperative complications that might otherwise ensue.

INDICATIONS FOR THORACOTOMY

The indications for thoracotomy in the forward area have been the subject of much discussion. Out of the early confusion a rather clearly defined policy has evolved that has proven its worth. We believe that thoracotomies in the forward area should be done for the following indications: 1. Possible thoraco-abdominal injuries; 2. Large chest wall defects (traumatic thoracotomies); 3. Miscellaneous indications, (a) suspected injury to the heart that might be amenable to repair, (b) severe continuing intrapleural hemorrhage of whatever source, (c) possible esophageal damage, (d) large bronchial fistulae from injury to the trachea or a major bronchus, (e) removal of excessively large intrapleural or intrapulmonary foreign bodies (such foreign bodies will in most instances have produced a traumatic thoracotomy in traversing the thoracic wall).

Although the numerical list of indications for thoracotomy in the miscellaneous group is large, the actual incidence of such being the indication for operation is small. Much emphasis [25] has been placed on continued intrapleural hemorrhage as an indication for thoracotomy. No one can argue that such a condition is not an indication for thoracotomy, but it has been the universal experience of those doing forward surgery that this is a rare rather than a common condition. It has infrequently been necessary to do a thoracotomy for continuing hemorrhage. (Table VIII). Also it is obvious from the records of our Group that some surgeons have operated for supposed continued hemorrhage without adequate evidence that the hemorrhage was continuing. It is difficult to generalize on how much bleeding constitutes life-endangering hemorrhage. Bleeding of such severity from the pulmonary parenchyma is exceedingly rare. That which does occur is mostly from one of the systematic vessels or from the heart itself. We [26] have found the following criteria to be the most reliable guides to serious continued hemorrhage:

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(1) A blood pressure which fails to rise with apparent adequate blood transfusions in amounts as high as 2500 cc., or having risen to relatively normal levels, falls again; (2) Re-accumulation of 1500 cc. to 2000 cc. of blood in the pleural cavity within 24 hours of the initial aspiration of a similar, large amount; (3) Persisting severe anemia in spite of blood replacement, as determinated by serial hematocrit readings.

INCISION FOR THORACOTOMY

There has been considerable discussion regarding the classification of thoracotomies as to whether they were "through the wound", "through a separate incision", or "limited thoracotomies". This has been done in an attempt to differentiate between the comparatively major and comparatively minor intrathoracic procedures that are carried out. There is considerable doubt if such a distinction accomplished this purpose. There is not necessarily any correlation between the location of the incision and the extent of the needed repair work. It is similar to classifying abdominal operations into small laparotomies and large laparotomies. It is our opinion that too much stress has been placed on the question of incision, i.e., whether through the wound or through a separate incision. To us, THE PARAMOUNT QUESTION TO BE ANSWERED IS WHETHER OR NOT THERE IS AN INDICATION FOR A THORACOTOMY. Once that has been decided in the affirmative, selection of the site of incision is simple. If there is a wound so placed on the thoracic wall that it involves the area chosen for thoracotomy then the operation should be carried out through an extension of this original wound. We are strongly opposed however, to using the wound unless it is placed in the area of election. The incision should be selected with one consideration in mind and that is gaining maximum exposure of the desired area. In other words, the location of the thoracic wall wound itself has no bearing on the indication for a thoracotomy. Such a wound should not be enlarged into a thoracotomy any more readily then the surgeon would proceed with a thoracotomy through a separate incision for the same lesion.

We are again in agreement with the Theater policy of advising a posterior approach for practically all thoracotomies. It not only permits the best exposure to most of the chest but such a wound is much more readily closed, and is not subject to as many complications as an incision in the relatively thin anterior thoracic wall. Practically the only exceptions to this rule are the traumatic thoracotomies and the occasional cardiac wound in which an anterior approach

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(Incision for Thoracotomy cont'd.)

may be preferred. In carrying out an anterior thoracotomy, an intercostal incision is definately better than resecting a rib because the former permits a much more satisfactory type of wound closure. Resection of an anterior rib often leaves a soft thoracic wall.

In dealing with thoraco-abdominal wounds or when such are suspected, consideration should be given to the projected course of the missile in selecting the site of incision. Too often attempts are made to deal with these lesions through incisions too low on the thoracic cage. This is especially true if the missile has gine through the 11th or 12th ribs. Resecting one of these ribs does not give adequate exposure for exploration. As a general rule, it is best to use the ninth or tenth rib (or corresponding interspace) for lesions involving the posterior segment of the diaphragm and either the ninth or eight rib for lesions of the mid-or anterior diaphragmatic portions. Some surgeons have employed a combined incision for certain thoraco-abdominal injuries. That is, extention through the chondral margin on to the abdominal wall. It is our opinion that such an incision is to be avoided because of the resultant instability of the thoracic cage and the increased morbidity should wound infection in the costal cartilages ensue. It may also be stated that wide exposure is to be commended. If the surgeon has reason to inspect the interior of the thorax he has reason to explore it completely.

The wound of the anterior, superior chest presents a unique problem in exposure if it is necessary to expose the large vessels in the superior mediastinum and base of the neck. The mediastinal portion alone can be quite well managed intrathoracically, but so often the exact point of injury is undertermined preoperatively that it is necessary to have exposure of both the cervical and mediastinal portions of the vessels. In such instances a curving anterior incision exposing the base of the neck, clavicle, and lateral half of the sternum on one side has been the most satisfactory. A section of the manubrium with the sternoclavicular joint can be reflected outward by previously dividing the clavicle. In this manner all the major vascular structures can be exposed and if the pleura has not already been damaged the operation can be done extrapleurally. When available, a Gigli saw makes the sternal and clavicular sections easier to accomplish, (Figure 59).

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(Incision for Thoracotomy cont'd.)

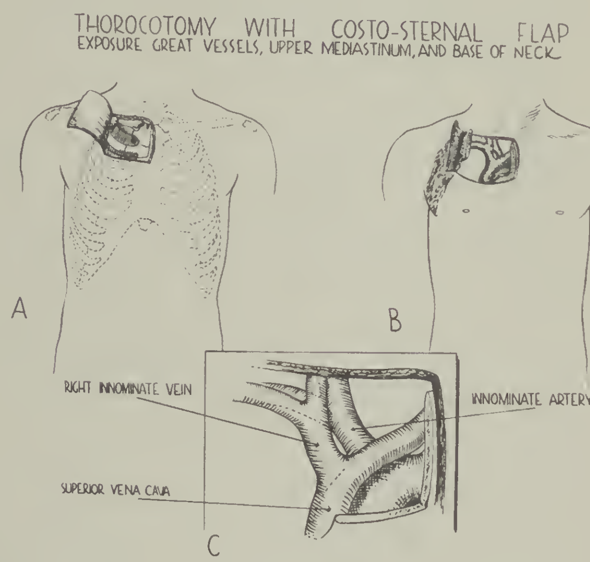

Figure 59 - (Modified from Harken). See text.

THORACOTOMY FOR THORACO-ABDOMINAL INJURY

DEFINITION: There has been some confusion due to inadequate definition. A thoraco-abdominal injury signifies that the missile has entered or traversed both the pleural and peritoneal spaces. This necessitates perforation of the diaphragm. All injuries that involve the chest and abdomen by the same missile are true thoraco-abdominal injuries. If separate foreign bodies have entered each of the cavities they are not true thoraco-abdominal lesions as the diaphragm has not been injured. As surgical procedures may differ from those employed in thoraco-abdominal injuries, cases with separate injury to the thorax and abdomen are better termed combined thoracic and abdominal injuries.

<u>POSSIBLE THORACO-ABDOMINAL INJURY:</u> It is of paramount importance to explore every thoraco-abdominal injury just as much as a laparotomy is indicated in every suspected abdominal penetration. The various factors that influence the selection of the proper approach - that is whether through the chest or through the abdomen - will be considered in detail below. Inasmuch as all but 66 of the 903 thoraco-abdominal wounds treated by our Group showed the path of the missile to be from thorax to abdomen, it is readily apparent that most of the questionable cases will show thoracic involvement without peritoneal injury in those cases that prove to be non-thoraco-abdominal lesions. Therefore, it is wise to explore the chest first in any doubtful case. That such a policy has been followed in our Group is indicated by the figures in Table VIII. It was found that 122 thoracotomies were done for suspected diaphragmatic penetration but none found at operation. The importance of this group is more readily appreciated by noting that it comprised 28% of all thoracotomies done in the forward area even when the positive thoraco-abdominal lesions are excluded. In all these cases it was obvious clinically that the abdominal damage would have to be confined to the vicinity of the diaphragm and could be handled transdiaphragmatically. This figure for negative exploration may appear high to the inexperienced, in comparison with the number of negative abdominal laparotomies that have been done for suspected abdominal injury. The discrepancy is attributable to two factors. The first is the difficulty of ascertaining by clinical means whether or not an organ in the upper abdomen has been injured such as the liver or spleen, and which may be associated with a paucity of the usual abdominal signs or symptoms. The second is the fact that lesions of the lower thorax often produce abnormal signs in the upper abdomen. The lethality of untreated abdominal injuries is such that exploration must be carried out in each instance where there is any doubt. The only cases that permit any other course are those in which small foreign bodies can be demonstrated to lie within the right lobe of the liver. If such missiles are but two mm. or three mm. in diameter the chance of their producing sufficient damage to warrant exploration is remote. Any foreign body larger than three mm. should be considered of sufficient size to demand exact knowledge of the damage it may have produced.

<u>APPROACH:</u> No hard and fast rule can be laid down as to the operative approach for all cases[15]. The question is whether it shall be through the chest or through the abdomen or both. The choice is dependent on three factors. First, whether the abdominal damage can be repaired

more easily from above or below; second, whether more extensive damage is expected in the chest or in the abdomen; third, the personal choice of the surgeon which is dependent on his training and experience. Thoracic surgeons tend to do more cases from above while abdominal surgeons take the opposite stand and prefer to do as many as possible through the abdomen.

What are the advantages of each approach? The transthoracic method will be presented first. There are eight factors that need to be mentioned. 1. If there is much thoracic as well as abdominal damage, the thoracic part cannot be done from below. 2. Certain upper abdominal lesions are more easily handled through the diaphragm. This applies to the spleen, splenic flexure of the colon, upper portion of the stomach (especially if the posterior surface is involved), the dome of the liver, and both kidneys. 3. Diaphragmatic repair is best accomplished transthoracically. This is true of both the right and left sides. Small lesions of either side may be closed adequately through the abdomen. But, those over the liver dome and large defects such as result from the tearing of the diaphragm from the costal margin, especially posteriorly, must, in most instances, be repaired from above. 4. It permits exteriorization of the transverse or splenic flexure of the colon through a subcostal gridiron incision at a greater distance from the operative incision than is possible if a laparotomy has been done. Wound infection is thereby reduced to a minimum. 5. Postoperative pain is less severe from a thoracotomy than from a laparotomy. During thoracotomy the two accompanying intercostal nerves are easily exposed and crushed with a hemostat. Having less pain the patient will aerate the lungs more adequately - and raise bronchial secretions more completely than if he is experiencing discomfort from an abdominal incision. 6. If marked pleural contamination is present due to a lacerated stomach or colon, copious pleural lavage with normal saline solution will decrease the severity of the pleural infection. Such a procedure is possible only through the chest. 7. The patient may be carried in a light plane of anesthesia during a transdiaphragmatic laparotomy as abdominal relaxation is not necessary. 8. Although it may not be apparent preoperatively, considerable damage to the intrathoracic organs may be present. This will not be determined and its repair, therefore, not accomplished if the exposure is an abdominal one.

The factors favoring an abdominal approach are two. 1. It is indicated to repair lesions of the lower ileum, cecum, ascending, lower decending, sigmoid and hepatic flexure of the colon. Many of these structures cannot adequately be exposed transdiaphragmatically.

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In such instances, laparotomy is mandatory. 2. Should the thoracic disturbance be minimal and operative therapy not indicated, (such as a small hemothorax or minor perforation of the lung) an abdominal exploration prevents entering another serous cavity, provided that the diaphragmatic repair can be done from below.

It is apparent, therefore, that certain lesions are best done from above and certain others from below. Inasmuch as most of the abdominal damage will be found in the upper abdomen it is advisable to do all questionable cases from above. Also, if it appears that there has been appreciable damage in the thorax the lesion is best approached through the chest. Should such exploration reveal abdominal lesions that cannot be exposed adequately one should have no hesitancy in doing both a thoracotomy and a laparotomy. If the thoracic physiology is restored by the thoracotomy the patient is in better condition to withstand a laparotomy. Finally, one must take account of the experience and qualifications of the individual surgeon. We do not submit that the performance of a thoracotomy is a difficult procedure nor that the postoperative management of patients subjected to intrathoracic operations is difficult. The general surgeon however, whose experience in modern thoracic surgery has been limited, does not fully appreciate the importance of securing air-tight closure and stability of the thoracic cage, complete and rapid re-expansion of the injured lung, and the maintenance of a clear tracheo-bronchial passage during the postoperative period. If the surgeon is not conversant with these objectives and the means of securing them it is safer for him to utilize the abdominal approach.

OPERATIVE TREATMENT: The abdominal phase of the repair of thoraco-abdominal lesions does not differ from that of the plain abdominal injury, and as the thoracic phase will be presented below it is not necessary to discuss these factors in any detail at this time. There are two points of particular significance in relation to thoraco-abdominal lesions that we wish to emphasize.

The diaphragm can be repaired by many different methods. Inasmuch as there have been reports of bile empyemata [27] on the right side and diaphragmatic hernia on the left, it is necessary to repair the diaphragmatic defect as securely as possible. In our hands, a two layer closure has been found the most satisfactory. This may either be by imbrication of two cm. of the diaphragm or by simple approximation re-enforced by a second layer of inverting mattress sutures. All sutures are of cotton or silk and all are placed interruptedly. This type of repair is seldom possible through an abdominal approach. In general we have felt that there are few indications for crushing the phrenic nerve.

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Any hepatic lesion that warrants exploration should be drained by some means. Packing is rarely indicated and the standard Penrose drain is the usual one employed. The drain or pack is brought out subcostally in such a manner as to provide dependent drainage. This means that the incision should be placed as far laterally as possible in order to avoid collections in the gutter, or, the liver laceration can be drained by the shortest route to the outside with an added drain in the right gutter. The drainage incision should be at least four cm. in length thru all layers of the abdomen wall and not a simple stab wound [28]. Certain innocent appearing liver perforations may have damaged the larger bile radicals and such cases may subsequently drain large amounts of bile. This may cause bile peritonitis or a disruption of the diaphragmatic suture line if adequate drainage is not employed. The amount of drainage that escapes through the drain is variable, depending upon the amount of damage. Likewise, the period during which drainage may continue is unpredictable. One should err on the side of leaving the drains in place too long rather than to remove them too early. This problem should seldom confront the forward surgeon as in most instances it is best to leave the drains in place until the patient is evacuated to the base. (See also section on Hepatic Wounds, page 307)

TRAUMATIC THORACOTOMIES

Traumatic thoracotomies have been arbitrarily defined [6] as any lesion of the thoracic wall that when debrided leaves a pleural defect six cm. or greater in one diameter or destruction of three or more ribs and all intervening structures. (Our use of the term is comparable to the term traumatic amputation. If, as a result of trauma, an extremity is completely amputated or so badly damaged that an adequate debridement results in an amputation, the term traumatic amputation is used). Such extensive damage to the thoracic wall, in practically every instance, results in some damage to the underlying lung as pulmonary lacerations or retained fragments. Thus, some intrathoracic manipulation may be indicated inasmuch as the exposure has already been obtained by debridement of the wound. They must be classified as thoracotomies, therefore, even though the intrathoracic damage in itself is not an indication for thoracotomy during the early treatment. These large chest wall defects have not been given as much recognition as they deserve and are not even mentioned in most articles or directives.

The size of the pleural defect is admittedly an arbitrary figure. In some instances smaller pleural defects permit the removal of a foreign body or the suture of a lung laceration. The important distinction to be kept in mind is that the size of the pleural defect following debridement is such as to permit any indicated intrapleural

manipulations. BUT SUCH INTRAPLEURAL LESIONS ARE NOT IN THEMSELVES INDICATIONS FOR THORACOTOMIES IN THE FORWARD AREA. THE INTRAPLEURAL PART OF THE OPERATION IS ENTIRELY SECONDARY.

This group of cases is the second of the two main indications for thoracotomy in the early treatment of thoracic war wounds. These wounds are most often caused by a fragment of high explosive shell. In some instances a bullet striking the thoracic cage tangentially or emerging from the chest in an erratic manner produces a disproportionately large thoracic wall defect. The size of the foreign body is not necessarily proportional to the size of the defect. The velocity of the missile and whether or not a rib is encountered seem to be of more importance.

A traumatic thoracotomy is performed through the wound of exit if it is a perforating wound or through the defect in a tangential wound. Since it is desirable, and in many of the large thoracic wall defects imperative, that the wounds be closed, including the skin, we have felt that they should be debrided even more radically than those that are to be left open.

As much of the ribs and intercostal structures as possible should be preserved to prevent paradoxial motion of the chest postoperatively. We, therefore, removed only the loose fragments of bone, and tissues that were devitalized. Rib fractures that have not penetrated the pleura are left strictly alone. The rough, sharp edges of rib stumps are smoothed up with the rib shears. The inner or outer table alone of the fractured rib may be displaced. In such cases the remaining half is left in place as a half rib gives more support than no rib. All damaged intercostal bundles are ligated anteriorly and posteriorly when observed to be bleeding at the time. When easily accessible the nerve is crushed but not included in the suture ligatures. To prevent postoperative pains and to encourage full respiratory excursion, the nerve accompanying the rib above the lesion is crushed. A paravertebral intercostal block of all nerves on the injured side that were not visualized and crushed at operation is advisable.

Some ingenuity is often necessary to effect an adequate closure of the chest wall. Intercostal structures are used where possible (Figure 60A-F). In some instances catgut pericostal sutures have been used to approximate separated ribs and reduce the size of the costal defect. Low on the thoracic cage near the spine, we have frequently had to swing a flap of the paraspinalis muscle to close the defect (Figure 61AB). Anteriorly the pectoral muscles (Figures 62 and 63) and recti are all that are available. If possible, these are used, if not, one has to rely on the subcutaneous fascia and skin. Rarely, one may have to resort to using the diaphragm to effect a closure of certain strategically placed defects on the lower thoracic cage. Generalizations cannot be made regarding the closure of these large defects as each case has to be individualized. The amount of available muscle for use is of great importance.

A.

Figure 60A - See Text

Every advantage of that obtainable must be utilized by such procedures as splitting it to make two layers (Figure 64), imbricating it with the existing intercostal bundles, etc. Relaxing incisions at a distance from the wounds are often of help and extensive dissection and freeing up of the subcutaneous tissues is a necessity. All tension on suture lines is to be avoided to the greatest extent possible.

The dressing of traumatic thoracotomies should be applied with care. It would give maximum support to the thoracic cage by use of "Ace" bandage or a liberal amount of wide adhesive passing to or beyond the midline

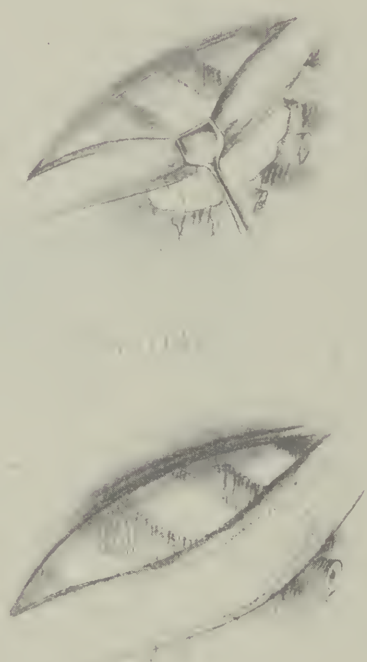


Figure 60B,C- See Text. (Latissimus loop flap).

both anteriorly and posteriorly. The skin is first painted with tincture of benzoin or "Ace Adherant" to secure good traction and to prevent skin blisters that often form when adhesive is applied tightly without this precaution. Such a supportive dressing minimizes the paradoxical motion of the chest, keeps the muscles and thoracic cage in approximation and, by restricing motion and therefore pain, aids the patient in expectorating material from the tracheobronchial tree.

Initial surgery of the Thorax and Thoraco-abdominal Wounds (Traumatic Thoracotomies, contd)

Figures 60 D,E and F -

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Traumatic Thoracotomies, contd)

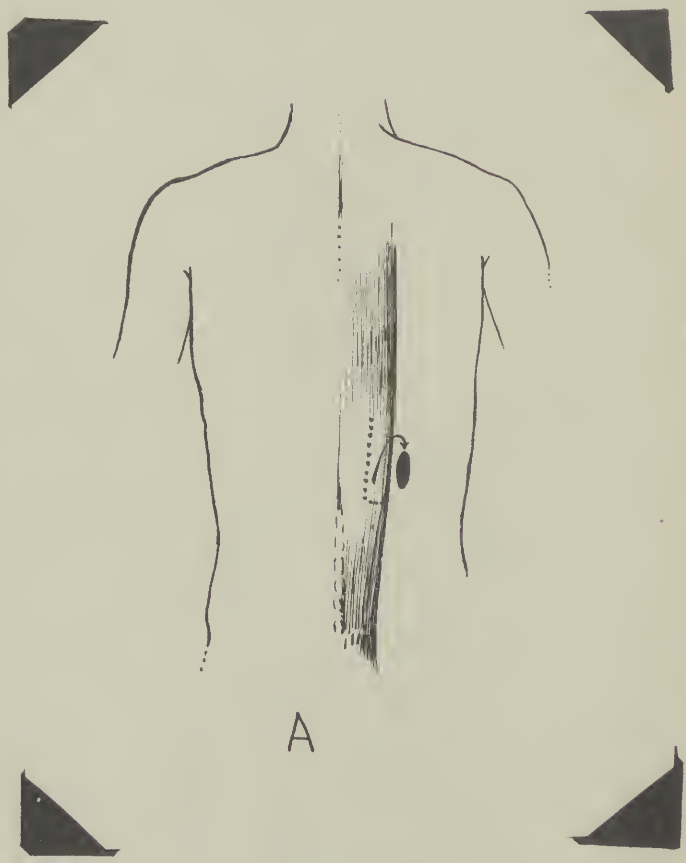


Figure 61 A - See Text.

Figure 61 B - See Text.

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Traumatic Thoracotomies, contd)

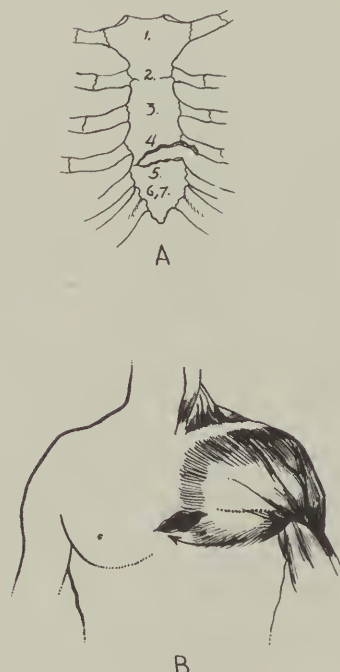


Figure 62 A,B- See Text.

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Traumatic Thoracotomies, contd)

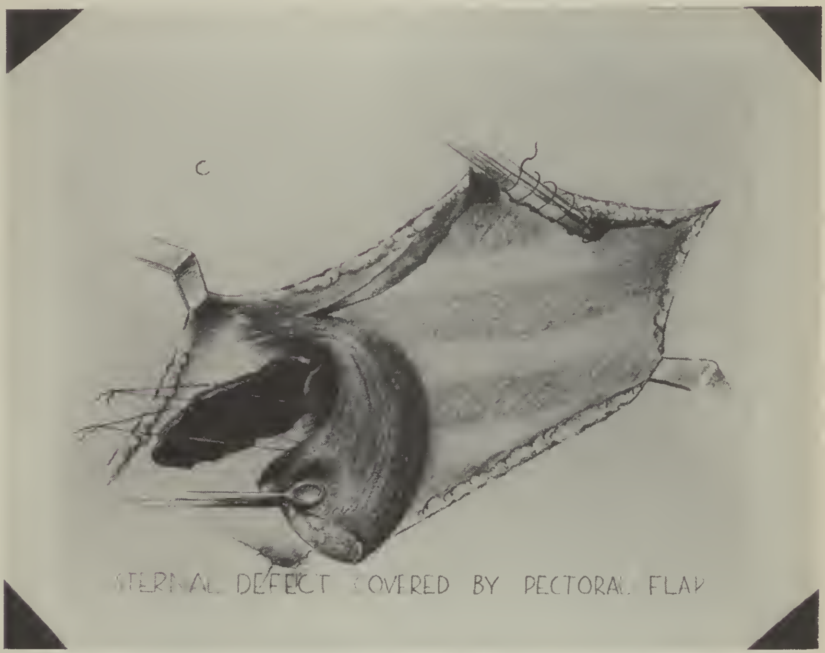
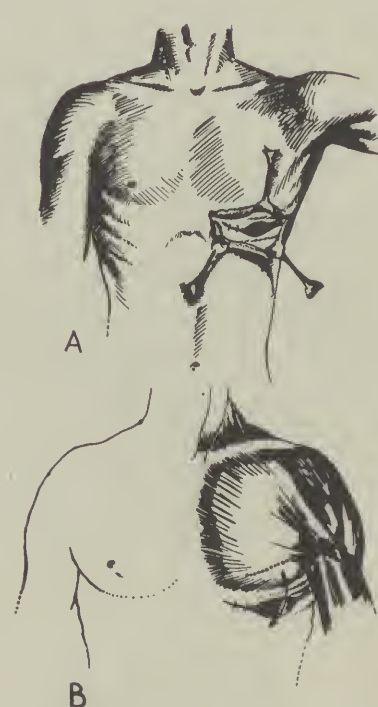


Figure 62 C - See Text.



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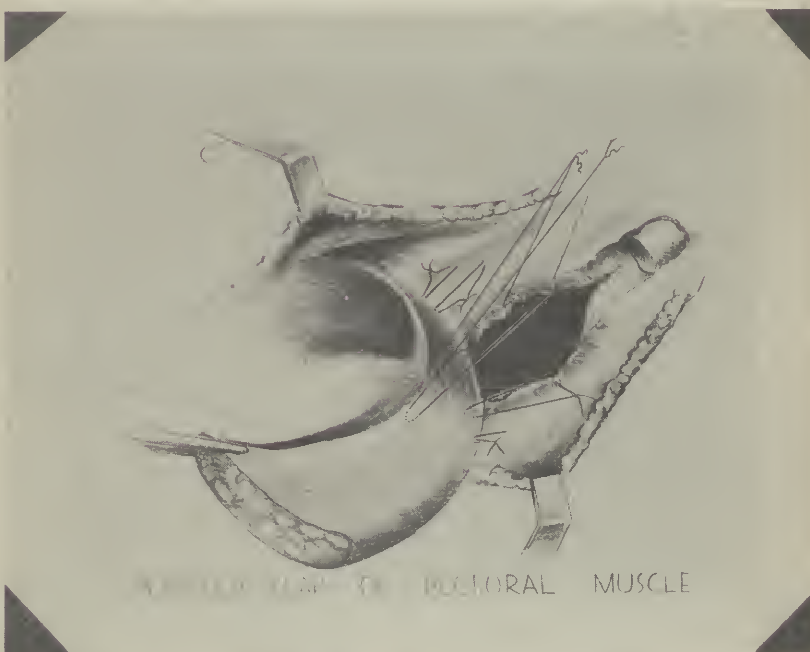

Figure 63 C - See Text.

Figure 64 - See Text.

INTRATHORACIC PROCEDURES

Intrathoracic manipulations indicated in the thoracotomies done in the forward area are few in the majority of cases. Foreign bodies that are readily available are best removed to prevent a secondary operation at a later date. If the thoracotomy was undertaken for some indication other than removal of the foreign body this procedure is relegated to a minor position. At this early stage, the lung is always the site of contusion and induration due to intrapulmonary hemorrhage and edema which make foreign body localization by palpation a more difficult procedure than at a later date when the acute reaction has subsided and been absorbed. Therefore, it is unwise to prolong the operation unduly or subject the lung to more trauma by searching too diligently for a small foreign body.

Bone fragments are more often found in the lung than are metallic foreign bodies (Figure 65D). Again, judgment is necessary in regard to their removal. Certainly, those that are easily found should not be left in place. As bone fragments usually are not seen on the preoperative X-ray, only those either seen or felt at operation will be recognized. Therefore, prolonged search is unlikely, such as might be undertaken for metallic missiles. It seems to us that those spicules of bone that are found partially in the lung and partially in the pleural space are the ones most apt to give rise to later complications. Fortunately they are also the most easily found and removed.

Lacerations of the pulmonary parenchyma (Figure 65A-C) will be encountered in practically all thoracotomies as any perforating lesion of the lung must necessarily cause some sort of a wound. This may vary from a small puncture wound to a very extensive laceration. It has been a source of amazement to all those doing forward thoracic surgery to observe the tremendous recuperative power of the lung. At first, all had the belief on seeing these badly contused, lacerated, hemorrhagic, boggy lobes that probably they should be resected. Yet, in practically every instance it has not been done because of the patient's poor general condition or other associated major wounds. Such cases have been closed with trepidation and with the expectation of all sorts of postoperative complications from the damaged lobe. In our experience, however, they have almost universally cleared in a comparatively short time and when one views the postoperative roentgenogram two to three weeks later it is almost unbelievable to see the apparently normal lung fields. The records of our Group show only a single instance of a resection of a lobe being carried out in the early treatment. That patient died during the operation. Pneumonectomy was not attempted in any instance. It is interesting to compare our experience and the results obtained, with the opinion of those who were dealing with similar cases in World War I (29).

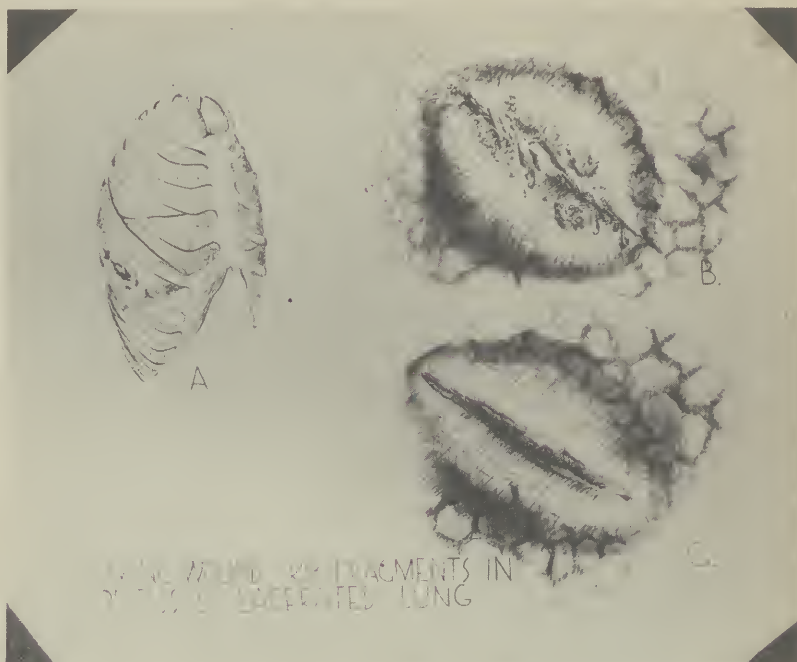

Figure 65 – A. Location of Wound.
B. Exposure of contused and lacerated lung with retained rib fragments.
C. Appearance of laceration following removal of bone fragments and detritus.

It apparently was their belief that all such hemorrhagic infiltrations or "splenization", as they called it, had to be resected to prevent a fatal issue. The great recuperative power of the lung is due in part, we believe, to the manner in which it derives its blood supply. As all the major vessels branch out radially from the hilus it is necessary to divide them near their origin in order to do irreparable damage to the lung parenchyma. Undoubtedly such lesions occur, but with damage to the large hilar vessels the patient usually succumbs and does not even reach the Field Hospital. It is also of interest to carry the speculation a bit further. It has been found by engineers that the best protection for wiring in airplanes is to simply fasten the wires loosely along the side of the plane. Thus, missiles are able to pass through the group of wires without doing much damage. When the same wires were placed in a conduit, a single bullet striking the conduit would completely divide all the wires. The same phenomenon is probably active in the lung. The blood vessels are surrounded by a fragile, elastic medium and hence they can easily be displaced in any direction by the foreign body. By being so displaced they usually escape severe damage.

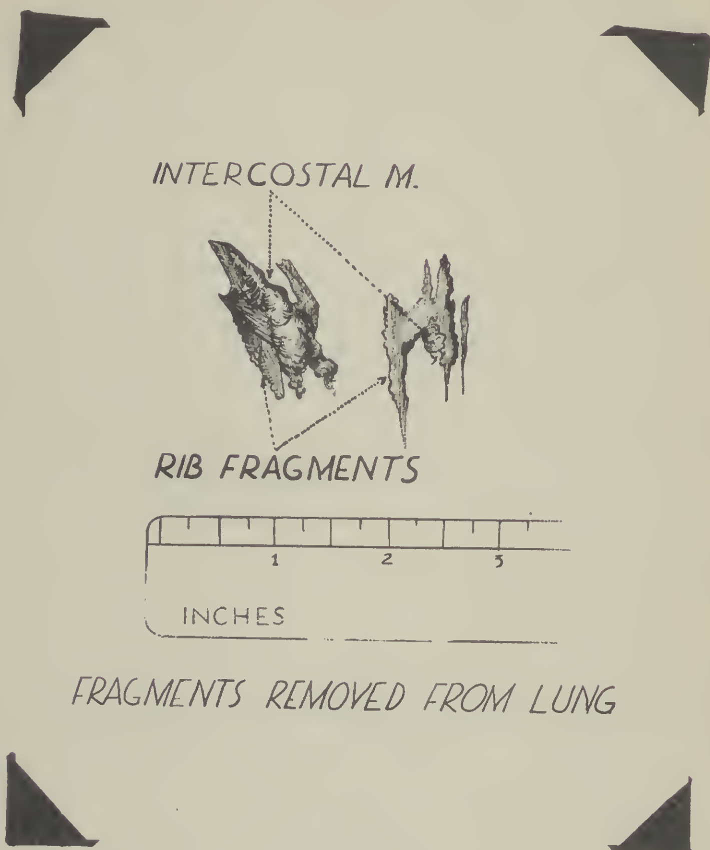

Figure 65 - D. Bone fragments.

Those lung lacerations that are oozing actively when observed, or those that present marked air leaks are best repaired with a row of interrupted sutures. There is some discussion as to whether other lung lacerations should be so treated or left alone. Some feel that it is better to close most of them trusting to internal drainage through the bronchi to care for any collection of material within the lung. Others believe that the smaller ones should be left alone, feeling that the pleura is better able to cope with any discharge than is the bronchial tre. It is the practice of most of us to test all the lung lacerations at the time of operation by use of 10 cm. to 15 cm. of water positive pressure with the hemithorax sufficiently full of normal saline solution

completely to cover the lung. Those lacerations that are so demonstrated to leak air or have been noted to be oozing blood are repaired. Others may be left alone. If the chest is to be drained, a small air leak is unimportant; if the chest is to be closed without drainage, any questionable laceration is best repaired. It is the experience of most of us that a single layer of interrupted nonabsorbable sutures is the most satisfactory. The deeper, hemorrhagic layers will not hold the sutures, therefore the visceral pleura only is closed.

Wounds of the trachea and major bronchi producing large air leaks are uncommon but one must be on the lookout for them. Their presence is most commonly suspected by projecting the course of the missile, and inability to completely re-expand the lung in spite of repeated aspirations or the use of a catheter with under-water seal. If the latter method is used it will be noted that bubbles of air are expelled during quiet expiration. Although our combined experience with lesions of the trachea and major bronchi is not large (four cases) the above findings have been present in all. When there are just grounds for suspecting such an injury, a thoracotomy is warranted, generally a high posterior approach gives the most adequate exposure. Repair is best affected by a simple closure with interrupted sutures. Conceivable severe damage to a bronchus may warrant resection of the lobe or the lung but we are not aware of any such lesion being treated in the forward area.

As was to be expected from civilian practice, esophagal lesions are particularly dangerous. Their detection is frequently difficult. If there is reasonable evidence of such from the course of the missile, or perhaps some blood on passing a Levin tube or occasionally a history of pain on swallowing or a widened mediastinal shadow by X-ray, exploration is advisable. (It is to be remembered, however, that hemorrhage may also give a widened mediastinal shadow. Although such cases will be explored in most instances, all the possibilities must be considered). Injuries to the esophagus are not common and in our series the results even with operation were poor. We have records of only six cases of injury to the intrathoracic portion of the esophagus. In three of these cases the lesion was not diagnosed until post mortem. Two of the others ended fatally and in the third the surgeon removed the missile from the wall of the esophagus and it is his opinion that the lumen of the esophagus was not entered. We, therefore, have no certain recovery from a proven intrathoracic esophageal penetration. The very high mortality justifies exploring any suspected lesion.

We believe that the best method of management is to expose these lesions, suture them with interrupted sutures, then if possible close the mediastinal pleura over the injured area and provide extrapleural drainage paravertebrally. If the extrapleural pathway is dissected out to the angle of the ribs from inside the chest, the track can be easily exposed through a short incision with rib resection and the drains inserted after

the thorax has been closed. There is one case in which this procedure was carried out but which ended fatally due to other lesions. He lived for five days without evidence of leakage from the repair or involvement of the pleura. Unfortuantely, in this instance, no post mortem examination was carried out.

Our experience is not large enough to warrant making definite statements nor are we prepared to state what is the best method of handling esophageal injuries postoperatively. It is our opinion that gastrostomies need not be done in the forward area for nutritional purposes. A Levin tube should be used either down to the site of repair for decompression as advocated by Sweet[30] in esophageal resections, or passed on into the stomach if the surgeon believes that to be preferable.

HEART AND PERICARDIUM

Among the total of 2267 cases with thoracic wounds, there were 75 instances of cardiac or pericardial involvement. This is an incidence of 3.3%. No individual team took care of more than ten cases. One of the 75 cases was a self-inflicted stab wound; the remainder were battle-incurred. There were 43 cases in the pure thoracic group and 32 cases in the thoraco-abdominal group. Of the 75 cases, 18 were examples of pure pericardial injury, and 57 patients had lesions of the heart itself. The soldiers were wounded by shell fragments in 53 instances, by small arms fire in 21, and by a knife (self-inflicted) in one. Among the pericardial cases, two wounds were caused directly by rib fragments, and at least one case of extensive contusion of the myocardium was caused by rib fragments acting as secondary missiles.

Diagnosis

It obviously has been difficult to diagnose cardiac wounds and injuries in forward hospitals. Electrocardiograms have never been available and roentgenograms have been limited to frontal and lateral films. Floroscopy should have been used more frequently. The data suggesting a cardiac wound as found on the case records has been supplemented by interviewing the individual surgeons. In more than 50% of the cases, the actual cardiac wound was undiagnosed prior to commencing surgery. The thorax was opened in the majority of these because of suspected thoraco-abdominal involvement, or for the debridement of large sucking wounds. In seven cases, continued hemorrhage of unknown origin (or merely suspected cardiac origin), either during resuscitation or at the beginning of surgery, prompted exploration. In three cases the presence of a foreign body in the mediastinum was an indication. In 15 cases (including two deaths in the shock ward) the cardiac wound was first discovered at autopsy.

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Intrathoracic Procedures, contd)

The suspicion of a cardiac wound must be predicated first, on recognizing the possibility that such a lesion exists and then, on considering the diagnostic criteria listed in Table XXIII. It is seldom that one finding alone will clinch the diagnosis.

Frequently the diagnosis may be suspected by thorough physical examination (Table XXIII) and accurate localization of external wounds. Plotting of the missile track often can be made with considerable accuracy when this examination is combined with roentgen studies showing the location of foreign bodies and the position of fractured ribs. Further proof can be gained when the foreign body is in the region of the heart and its outlines are roentgenographically recorded as fuzzy or double-contoured. In localizing missiles within the cardiac shadow, heavy penetration must be used, either by means of "bone technique" or the Potter-Bucky diaphragm. Often a missile will be completely overlooked in a thoracic film of usual exposure. Flouroscopy should be used more frequently to study the motion of the missile and whether or not it is included within the cardiac shadow in all projections. The cardiac outline may be altered, and has been described as "water-bottle", fuzzy or enlarged. In two cases where the outline was blurred or fuzzy, operation disclosed hemorrhage into the pericardial membrane and the areolar tissues of the lower mediastinum.

Symptoms of anoxia may be present in some patients with cardiac wounds. Before attributing these symptoms to a cardiac lesion, great care must be exercised in ruling out other causes of oxygen want such as hemorrhage, hemothorax or pressure pneumothorax and extensive peritoneal contamination. In the absence of severe external wounds, peritoneal contamination, etc., and following the application of resuscitative measures, there remain cases in which dyspnea, cyanosis, or mental confusion persist which are out of all proportion to the visable thoracic damage. Such evidence then indicates a cardiac lesion as the basis for continuing anoxia.

Direct evidence of cardiac dysfunction may be encountered. (Table XXIII) It is certain that more frequent cardiac examinations would lead to an increase in these findings. Thus, three medical officers made all eight observations of arrhythmias. As with anoxic symptoms, the observation of a continued rapid pulse must be predicated on ruling out other causes of tachycardia in the patient, before it can be assumed that the tachycardia is on an intrinsic cardiac basis. A soft systolic apical murmur is an exceptional finding (31). The one example of paradoxical pulse was noted in a patient with severe myocardial contusion, who died in the shock ward. Friction rubs were heard preoperatively on only two patients. In both, however, the friction rub was heard 24 hours after injury and operation was greatly delayed (three and five days, respectively). Since a friction rub or splash was noted in eight additional cases postoperatively, it is evident that a certain time interval is necessary for this sign to appear.

In comparison to the frequency with which it is noted in civilian cardiac wounds, tamponade has been an infrequent finding in this series. In war wounds, the missiles usually are larger and most often there is a pericardial laceration which allows drainage into the pleural cavity. The condition must always be looked for because of its lethal potentialitics. Death occurred twice due to unrecognized tamponade, although in one case, with a severe thoraco-abdominal injury, it was suspected. In this instance, exploratory puncture was not successful because all the blood in the pericardium had clotted. It should be remembered that in acute traumatic tamponade the blood often comes from wounds involving a cardiac chamber, but it may also come from a severed coronary artery branch, from the myocardium itself, or from a vessel in the pericardium. In the three cases the diagnosis was based on the findings of distended neck veins, muffled heart sounds and a "water bottle" appearance to the cardiac shadow. Here again, fluoroscopy can be used more frequently in depicting a decrease or absence of pulsation. Lowered pulse pressures were not noted. Hemopericardium of from 50 c.c. to 150 c.c. was noted in five cases at operation. In none had there been clinical evidence of increased pressure.

Pathology

The cardiac lesions as seen at surgery or autopsy have been classified as follows: Contusion, pure laceration, laceration with contusion, penetrating and perforating wounds of the chambers, and embolus to the heart. Cases in which foreign bodies were found in the myocardium or chambers were placed in the various pathological categories depending upon the type of myocardial injury produced, without respect to whether or not the foreign body was still present. In general, the signs and symptoms exhibited, the indications for surgery, and the cause of death differed in the various pathological categories. (See Tables XXIV, XXV.)

Insofar as operative therapy is concerned, contusive lesions are nonsurgical. Pathologically they are very similar to the contusions described by Beck[32], Elkin[33, 34], and others, occurring as the result of blunt trauma to the chest, "steering wheel" injuries and the like. In most instances of battle casualties, however, the pathogenesis is probably different in that the contusive force is propagated by the passage of a small high velocity missile in the immediate vicinity of the heart. In some instances in this series, the ribs or sternum (Figure 66) apparently acted as secondary missiles, causing blunt injury directly. The question of localized "blast" effect from the passage of the missile cannot be answered. Certainly, none of the contusions in this series was due to a generalized "blast" effect, i.e., a pressure wave in the atmosphere. While theoretically possible for serious cardiac injury to result from blast, it has not been observed by us, although always considered when performing autopsies on patients dying from blast injury.

Figure 66 - Fatal case in which contusion was caused by bullet exerting indirect force through sternum.

The pathology of contusive lesions consists of scattered or confluent petechial hemorrhages involving the myocardium over varying areas of one or two chambers (Figure 66). There may be superficial abrasions of the epicardium and the subepicardiel vessels may be engorged and thrombosed. The myocardial hemorrhage often extends through to the endocardium and the muscles itself may show gross evidence of degenerative change or actual necrosis. In fatal cases where there has been involvement of the entire thickness of the myocardium, mural thrombi are frequently found attached to the endocardium (Figure 67). With extensive lesions scattered along the acute or obtuse margin of the heart, it is not uncommon to see hemorrhage extending into the myocardium of both ventricles and a portion of the interventricular septum. In the group of contusions there was a death rate of 37.5% due to the heart lesion itself. Of the 16 cases of myocardial contusion, nine had an intact pericardium.

Figure 67 - Fatal case in which contusion mural thrombus formation followed wounding of myocardium by rib fragments acting as secondary missiles. The pericardium was intact in this case.

The other lesions may be classified as "potentially surgical" lesions. In the pure laceration category are placed all cases with incised or cleanly lacerated wounds of the myocardium, in which there was no gross evidence of myocardial contusion or necrosis. Two cases with foreign bodies in the myocardium are included here, since the myocardial wound itself fitted this classification pathologically. The less serious implications of wounds of this type is mirrored by the single death due to the heart in ten cases of pure lacerated wounds.

When lacerated wounds are associated with extensive contusion, whether or not a foreign body is present, the lesion is a serious one. In this category there was a 40% death rate due to the heart.

In wounds penetrating to the chambers of the heart, hemorrhage is the most frequent complication and the most important cause of death. The hemorrhage may be exsanguinating or cause tamponade. The death rate

in this pathological category was 50%. There were five cases of perforating (through and through) wounds of the chambers in this series. Two occurred in the left ventricle and both survived following suture. One of these cases has been reported in detail elsewhere (35). In three cases of perforation of the right auricle there were two deaths. No case of perforation of the interauricular or interventricular septum has survived to reach a forward hospital.

Cases of embolism to and from the heart form a small but interesting group. There were four examples in this series. In two, the missile came to rest in the right ventricle by way of the inferior venacava. In one, the situation was recognized and the 45 caliber bullet successfully removed (35). In the other case, the shell fragment "disappeared" after having entered the body through the right flank. Thoracic roentgenograms revelaed a questionable missile just above the diaphragm. The films were

Figure 68 - See Text, page 469.

repeated later using ordinary technique and the foreign body was not visualized. Over a period of ten days the patient had attacks characterized by decreased blood pressure, high fever, mental confusion, pallor, rapid pulse and "shocky" appearance. In retrospect these attacks could well have been due to myocardial ischemia. At autopsy, after sudden death, the right ventricle was found to be greatly dilated and the myocardium overlying the foreign body in the right ventricle was hemorrhagic and necrotic. (Figure 68) Had the condition been recognized, removal of the shell fragment probably would have been life-saving. As an embolus from the heart, the foreign body may enter the pulmonary circulation, become retrograde in the systemic venous circulation or enter the systemic arterial vessels. One case in this series entered the right auricle, dropped into the inferior vena cava and eventually was recovered from the left common iliac vein (36). In the fourth case, a bullet entered the left ventricle and came to rest in the right flank region, presumably the right iliac artery. The patient had no symptoms of obstruction.

Operative Findings and Treatment

Analysis of the records (Table XXVI) shows that a surprising number of wounds of the myocardium (10 out of 16) were not repaired. There seemed to be no immediate ill effect resulting from lack of repair. Further, of the cases of laceration seen at autopsy only, none of the deaths were believed to be due to lack of repair. The cases were listed as completely repaired if the edges of the laceration had been completely approximated with sutures. The two cases of partial repair were those in which complete approximation could not be obtained, and pericardium was used to help bridge the defect. Note was made of the use of free muscle grafts in only two cases. The use of the pericardium was frequently described, either sutured over the wound or sutured to the edges of a poorly approximated wound. When the pericardium was sutured over a wound it was drained posteriorly.

In 13 cases of wounds involving the cardiac chambers, complete closure was obtained successfully in 10 cases. One wound was not bleeding at the time of operation and was not sutured. In two cases of auricular wounds, closure was attempted and failed and the patients died of uncontrollable hemorrhage. In both, attempts were made to plug the defect in the auricular wall with the finger.

In 21 cases, the foreign body was described as in the heart or pericardium as indicated below:

Fate of Foreign Bodies

	Pericardium	Pericardial sac	Myocardium	Completely in chamber
No. of cases	4	3 (2 probable)	10	4
Removed	4	1	3	1
Not removed		2 (both probable)	7	3
Found at autopsy			(5)	(3)

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Intrathoracic Procedures, contd)

These figures show a low percentage of removal. The majority not removed were small fragments, 0.5 cm. or less. In several, the condition of the patient did not warrant further search. The foreign bodies marked "probable" were not definitely located, but from X-ray evidence and operative findings, their presence in the pericardial sac seemed likely. Of the eight foreign bodies found at autopsy, the missile was directly responsible for one death (embolus to the heart) and possibly for a second death.

Pericardium. There were 18 cases of pure pericardial injury. Three deaths occurred in this group, all more than 48 hours following operation and none due to the pericardial lesion. Of the 18 cases, there were 14 lacerated wounds and four with foreign bodies present, two metalic and two rib fragments. Of all the wounds in which the pericardium was opened it was sutured tightly in five cases; the remainder were drained into the pleural cavity. In two of the five cases (one, a pure pericardial injury, and one a myocardial wound) there was massive troublesome pericardial effusion postoperatively. This was not noted in the cases which were drained.

Time and Place for Cardiac Surgery. When confronted by a patient with a suspected cardiac wound, decision should be made if possible as to the type of pathology present in the heart and as to the presence or absence of a foreign body in the heart or pericardium. Two distinct questions must be answered. Can the cardiac lesion itself be corrected by surgery, and should this surgery be performed in a forward hospital or at the base? What is the effect of the cardiac status on the patient's ability to withstand needed surgery for other wounds? In contrast again to civilian cardiac injuries, the heart in all war casualties is but one of several organs injured and both the diagnosis and the decision as to time of operation are complicated by the presence of these multiple injuries. With these factors in mind it is gratifying rather than otherwise that nearly 50% of the cardiac wounds were recognized prior to operation.

The problem may be approached by considering each pathological classification of the heart more or less separately. When a cardiac contusion is suspected, decision may be difficult as to when to operate on concomitant wounds. As stated above, the contusion per se, is not a "surgical" lesion. The fact that six ouf of the 11 deaths in the contusion group were due to the heart shows that these patients probably are not good operative risks. The diagnosis of a cardiac contusion should not be extremely difficult since it has been noted in the present series that the majority of signs and symptoms indicative of oxygen want, and of cardiac dysfunction (persistent tachycardia, arrhythmia, etc.) were found in patients who had significant contusions of the myocardium. These signs, and the gross and microscopic appearance of the myocardium have much in common with the picture of myocardial infarction following coronary occlusion, and we have felt that these patients might well be handled as

if they had an acute coronary occlusion. If this analogy is carried further, then the first 24 to 48 hours is an extremely dangerous period for surgical intervention in that during this time the danger of death from an irritable myocardium and lethal arrhythmias may be enhanced by any anesthetic or operative manipulation. In many cases, however, attention must be given to other serious wounds, especially those with thoraco-abdominal involvement where undue delay in surgery often is disastrous. The best that can be done under these circumstances is to prepare the patient as thoroughly as possible consistent with the major surgical lesion. The mortality rate in such cases inevitably will be high.

There remains a group of cases with pure thoracic wounds in which early surgery (within six to 12 hours) usually is not mandatory, and in which delay because of a cardiac contusion may be practicable. Viewed from this standpoint the cases of contusion were carefully analyzed. There were three, all with a fatal outcome, in which it was felt further delay in surgery probably would have been beneficial. Two were pure thoracic wounds and one was a high rhoraco-abdominal wound in which it was obvious that only the liver was involved. The time between wounding and surgery was 5, 11 and 17 hours respectively. In each instance, signs of cardiac dysfunction were prominent. During the resuscitation period the patients remained in poor general condition with rapid pulse, semistupor, and dyspnea out of proportion to the visible intrathoracic damage, in spite of an increase of the blood presures to 95 or above. In each instance death occurred either on the operating table or shortly after the surgery was completed. We have also reviewed a fourth case, not included in this series, in which there was a pure thoracic wound, a six-hour lag, and sudden death on the operating table. At autopsy, this patient showed extensive contusion of the right ventricle and thrombosis of the anterior descending branch of the left coronary artery. While any of these four cases might well have died even if surgery had not been performed, the added burden of the anesthetic and an operative procedure cannot be ignored. In contrast to the relatively early surgery in these four cases, two cases may be cited in which surgery was considerably delayed (three and five days after wounding). Both were in shock on admission to the hospital and cardiac contusions were diagnosed. In one, the pulse remained over 120 beats per minute for 48 hours. In the second case, there were intermittent periods of cardiac arrythmia for four days, associated with wet lung, pulmonary edema and jaundice. In both cases there was recovery from surgery. It was our strong feeling that operation performed in either case at 12 hours or less could well have ended disastrously.

To summarize our beliefs, when a cardiac contusion has been diagnosed and indications for early operation, such as continuing hemorrhage or thoraco-abdominal involvement are not present, surgery probably should be postponed for a minimum of at least 24 to 48 hours to give every opportunity for the reduction of myocardial irritability.

As to the feasibility of operating in forward hospitals for the express purpose of suturing cardiac lacerations, no final conclusions can be drawn. With pure lacerations there are few if any symptoms of cardiac dysfunction and damage to the heart can only be suspected from the course of the missile or from a possible tamponade. Ten of the 16 lacerations exposed in this series were not repaired and of the remaining six, two were partially repaired. In no case was it felt that there was any immediate disability, nor were the deaths due to lack of repair. If a laceration is to be sutured, it is better accomplished at a forward hospital. It is probable that no efficient repair can be performed in a base section hospital five to 10 days after injury. Retraction of edges of the myocardial defect, with induration from fibroblastic tissue proliferation probably combine to defeat a good approximation.

Penetrations or perforations of the cardiac chambers, particularly of the auricles, are often manifest by continuing hemorrhage and early surgery is mandatory. If foreign bodies are found or it is suspected that they are in the chambers, an attempt should be made to remove them at the same time, but it should be remembered that the main indication for the operation is the control of hemorrhage, and long continued search or extensive blind manipulations within the chambers is not justified. If the missile is not found almost immediately, the defect should be sutured and further consideration given to removal of the intracardiac fragments at a base hospital.

If the bleeding causes tamponade rather than exsanguinating hemorrhage, treatment may be more individualized. Should the tamponade develop rapidly, it is probably better to operate at once, particularly if it is known that the missile causing the wound was large. If however, the tamponade develops slowly, one or two aspirations may suffice, without surgery, as has been suggested by Blalock and Elkin.

When foreign bodies are suspected of being in the pericardium or myocardium it is probable that their removal should be postponed until the patient can be evacuated to a base section center, unless there are early and continued episodes of cardiac dysfunction, or bleeding. The dearth of diagnostic facilities and the lack of time for unhurried study in forward installations often make accurate localization difficult. Two other factors enter into the considered opinion for a delay in the removal of cardiac foreign bodies. In the present series, nine of the 13 missiles believed to be in the pericardial sac or myocardium were not removed. In only one was it believed that death was possibly due to the presence of the foreign body itself. In addition, Harken[37] in a base section center has now operated on 40 patients with removal of the foreign body from the pericardium or myocardium without a death.

Metallic foreign bodies acting as emboli through the venous system to the right auricle or ventricle now are becoming recognized more

frequently (35). In the past, their removal has been the subject of much discussion (31) (38). While some have remained asymptomatic for a long period of time, others have caused death from embolism, focus of infection or myocardial damage. In the majority, it is probable that early removal in a base section center is the wiser policy. Harken has now removed a number of these without a death. On the other hand, recognition that the presence of the foreign body in the chamber is causing cardiac disability or emboli should be an indication for early removal in a forward hospital.

Comment on Exposure and Operative Techniques. When a cardiac wound in need of surgical repair is suspected, adequate exposure through an elective approach is mandatory. The tragedy of inadequate exposure is illustrated by a case of exsanguination from a wound of the right auricle which was unsuspected, and the operative incision was a low posterior thoracotomy for a thoraco-abdominal wound. The hemorrhage could not be controlled with the exposure given.

For most purposes an anterior approach is more suitable. An intercostal incision always should be employed unless the corresponding rib is badly fractured. The third or fourth intercostal space offers the best exposure for the auricles and the fifth or sixth for the ventricles. This approach should be transpleural. We feel strongly that no time should be wasted by attempting an extrapleural exposure of the heart. Such operations take longer and the exposure, particularly for posteriorly placed lesions, is not as satisfactory. We feel too that drainage should be provided into the pleural cavity. In addition, intrapleural damage and a hemothorax are almost always present, which would make extrapleural exposures even more difficult.

Ten c.c. of 5% procaine usually has been injected into the pericardial sac for several minutes before exposing the heart, following the suggestion of Beck. This materially cuts down the incidence of ectopic beats while the heart is being handled. Several maneuvers have been employed in manipulating the heart. For anterior lesions the "palming" method (31) or the Sauerbruch grip have advantages. By the former means, the third, fourth and fifth fingers are passed behind the heart, the index finger is passed in front and the thumb is free to apply hemostasis. This gives excellent control both of the heart and of the bleeding area. In exposing the diaphragmatic surface, some prefer the apical suture. The authors, however, feel that the hand of the assistnat makes a much better retractor (Figure 69). The apex of the heart can be rotated at least 90 degrees forward and the cardiac movement is considerably dampened by using the hand. By spreading the fingers a slotted type of retractor can be simulated which will expose any portion of the wall.

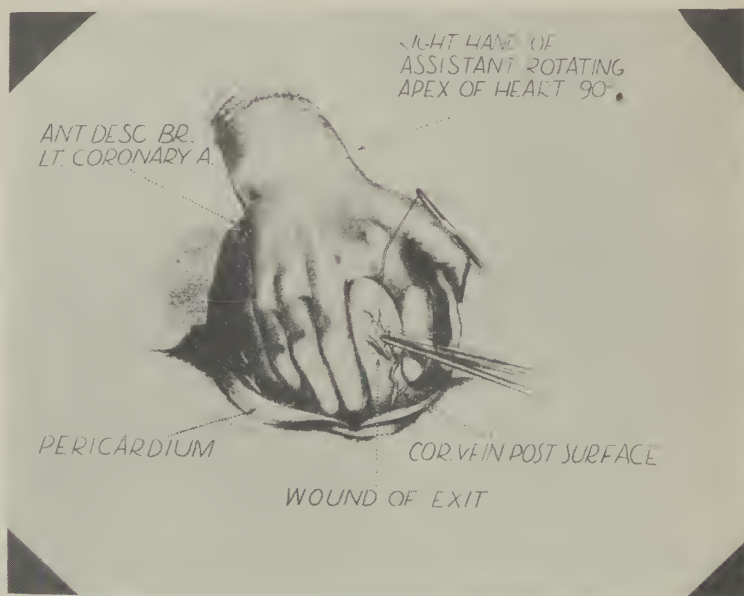

Figure 69 - See Text.

We owe much of our knowledge of the actual suturing technique to the well-known writings of Beck, Elkin, Bigger and others. The general directives which they have promulgated form the background for most cardiac manipulations. Our chief concern here, is the emphasis on certain techniques which are particularly valuable in dealing with large wounds. Suture materal should be of braided 0 and 00 silk, preferably waxed or oiled. A small-eyed or atraumatic round needle should be used. Interrupted suture technique always should be employed and the sutures placed close to the edge of the wound, tied during systole if possible, and without tension. Necrosis of the wound edges, particularly in wounds involving the chambers, may lead to secondary fatal hemorrhage. The sutures should not be passed throughh the endocardium as this increases the possibility of thrombus formation (Figure 70). In the repair of auricular wounds, however, this may be impossible to avoid. As discussed above, many of the lacerations in this series were not sutured and it is certain that some should be left alone since attempts at suture may lead to further difficulties. Such wounds include the superficial, nonbleeding :

Figure 70 - Illustrating the placement of sutures, avoiding the endocardium.

laceration of one or two millimeters in depth, particularly if they involve the left ventricle; round or oval lacerations, especially in the region of the apex; laceration near a major coronary vessel, the repair of which might cause thrombosis of the vessel. In general, laceration of the right ventricle are easier to suture than those of the left and since the wall of the right ventricle is thinner, it should be repaired more often. The justification for repair lies in the fact that the scar from a sutured laceration is stronger and the wall is thicker than if no repair is performed. Complete suture, or repair of some type is mandatory if the bottom of the laceration feels thin or if there is any bulging. Without adequate suture, later aneurysm of the myocardium may develop and cases of this kind have been reported by Loison (quoted by Lillienthal[31]). Some lacerations, because of loss of substance or surrounding contusion and necrosis of the muscle, are difficult if not impossible to suture completely. Considerable ingenuity must then be exercised, particularly when the laceration has opened a chamber. Free muscle grafts are useful in this connection and should be employed much more frequently. They can be laid in the defect and held in place by fine sutures.

This not only helps to fill the defect but is instrumental in stopping hemorrhage or myocardial ooze. As a further reinforcing mechanism, the pericardium always should be sutured over the area of repair, after first draining the pericardium into the pleural cavity posteriorly through a cruciate incision. The edges of the pericardium may be approximated or imbricated. Sutures may be taken into the epicardium and superficial myocardium at the edge of the myocardial defect. The pericardium combines very nicely with a free muscle graft in giving a solid repair (Figure 71 and 72).

Figure 71 - Use of free muscle graft; imbrication of pericardium over wound.

Wounds penetrating the chambers of the heart should be sutured even though not bleeding and plugged by clot when exposed. Secondary hemorrhage is frequently a complicating factor if this is not done. Large wounds of the auricle deserve special mention. Even three centimeter wounds of the auricles may not exsanguinate, because the lung collapsed against the wound, or clot has formed. The maneuver of covering the defect with the finger as employed in wounds of the ventricle cannot be

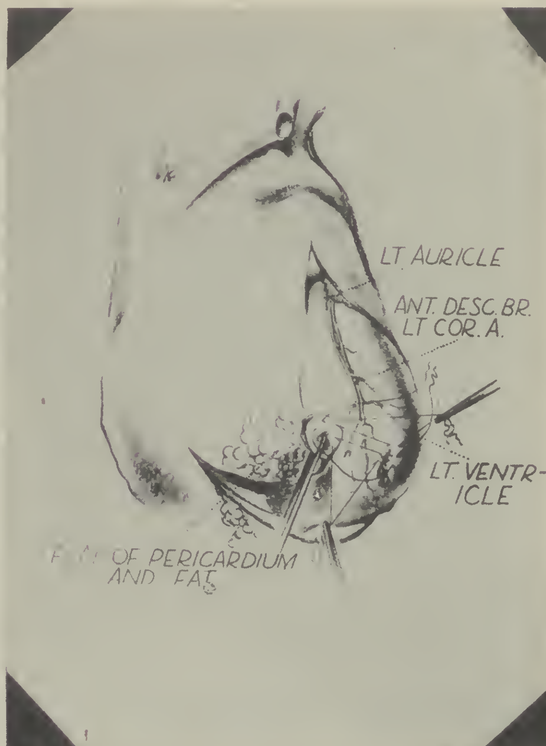

Figure 72 - Use of flap of pericardium as an extra layer, when bleeding is not completely controlled by myocardial suture.

used when the auricular chamber has been penetrated, because of the thinness of the wall. If sutures cannot be placed at once, each edge of the laceration should be grasped with fine forceps, which can then either be approximated, or ligated temporarily until sutures can be properly placed (Figure 73,1). If the wound is at the edge of the auricle, it can be completely occluded with rubber-shod forceps (Figure 73,2). Perforating (through and through) wounds of the chambers can be repaired successfully if both wounds are on the surface. No method of exposure has yet been discovered to repair a wound on the posteromesial surface of the right auricle. There were two cases of this type in the series and both died of exsanguination.

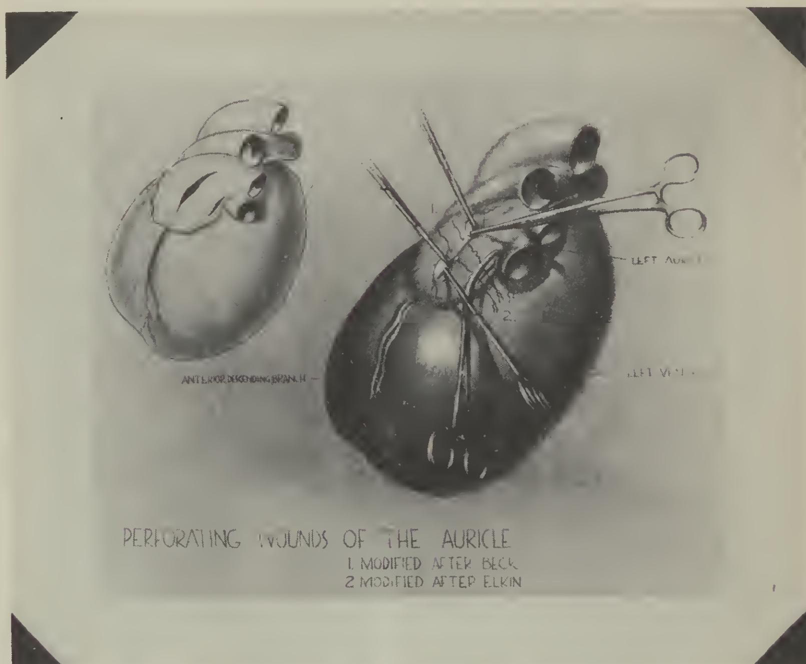

Figure 73 - See Text, page 477

When small branches of the coronary arteries are bleeding, meticulous ligature or suture of the individual branch is necessary. If fine clips are available, they may be used as Beck has suggested.

Postoperative Findings. In the patients that lived, certain findings relative to the heart were recorded. Seven patients developed friction rubs postoperatively and some were audible up to three weeks. Massive pericardial effusion developed in two patients in whom the pericardium was not drained at the time of operation. These were both relieved by pericardiocentesis and there were no sequelae. Two patients suffered significant myocardial accidents, probably myocardial infarctions. One of these was following the single stab wound in the series. The other patient developed a typical coronary occlusion 24 hours postoperatively

with transient auricular fibrillation, precordial pain and circulatory collapse. He had extra systoles before operation and at operation it was necessary to ligate a small bleeding terminal branch of the anterior descending artery. In addition, the patient had a superficial, clean laceration at the apex which was not repaired. One patient developed a hemiplegia after operation, at which a laceration of the left ventricle was described. One may speculate as to whether or not mural thrombi did develop in the left ventricle.

CLOSURE OF THORACOTOMIES

Pleural Lavage

After completing the intrathoracic repair it is advisable to remove all blood, blood clots and detritus from the pleural space. Most of this material is easily removed with the suction tip but there is always a certain amount of blood and clot that escapes detection and removal by this method alone. It is our opinion that the remainder is best removed by copious flushing of the pleural cavity with normal saline solution at body temperature. This is less traumatizing than the use of gauze sponges even though they be soaked in saline beforehand. Rubbing the delicate pleural surfaces is certain to produce some damage and this adds to the amount of pleural exudate in the postoperative period, as well as predisposing to the formation of pleural adhesions when the lung and thoracic wall come into apposition.

Some are of the opinion that normal saline should not be used as they feel that the remaining blood in the pleura is not irritating. There is much evidence, however, that blood in the pleura is an irritant. According to Yates[29], "Delrey and Middleton showed that blood is so irritating to joint and chest serosa as to produce a serofibrinous serositis". He also adds, "Irritation of serosa (pleural) provokes a very rapid serous effusion which occurs promptly with hemothorax and soon exceeds the amount of blood originally present." These quotations from the Medical History of World War I are of much interest as they indicate that they were approaching the problem of hemothorax in the correct manner. On the other hand, it is somewhat difficult to explain the statement made therein that, "Washing out the pleural cavity is a temptation to be resisted as the subsequent healing is poor". We have not found this to be true and it is our practice to flush out thoroughly the hemithorax with 1500 c.c. to 2500 c.c. of saline at the completion of any thoracotomy. The amount of fluid so used is not of importance. The important thing is to continue the flushing until the return is clear, indicating that all the blood has been washed off the pleural lining.. Although this practice has resulted in considerable discussion it seems a very logical procedure and one that most of us used routinely in civilian practice. It is not a new procedure as has been supposed by some. It is our opinion that this cleansing of the pleura reduces the amount of postoperative effusion thus making for a smoother convalescence.

If the chest is to be closed without drainage, great care should be exercised in securing complete lung expansion at the time of closure. Apposition of the lung and thoracic cage is of paramount importance. We have found that it is most easily obtained in the following manner: As the pleural closure is started, the anesthetist gently increases the intrabronchial pressure to plus 5 cm. to 10 cm. of water. A 22F catheter with at least two holes in the tip is inserted into the chest through the pleural sutures and so placed as to lie in the uppermost portion of the chest. The suction machine is then attached to the catheter which has an air vent, previously made, near its proximal end. This prevents too much suction which might damage the lung but does provide encouragement toward expansion. The pleural closure is then completed. When the pleural repair is finished, the intrabronchial pressure is increased by the anesthetist to 15 cm. to 20 cm. of water. At the same time, the surgeon carefully increases the suction on the catheter with his finger. A suture is placed around the catheter by the assistant, the catheter is slowly withdrawn and the suture tied to prevent any ingress of air through the small defect.

Pleural Drainage

If the chest is going to be drained with under-water drains, such extensive precautions to obtain complete, prompt pulmonary expansion as enumerated above are not necessary, since any residual air or fluid will be expelled through the drains. It is wise, however, to expand the lung at least once just before closure to be sure the lung is expansible. The question of chest drainage following thoracic operations is one that is best decided by the individual surgeon as it will depend on many factors such as the physical location of the hospital, the adequacy of the nursing care, the lesions that were present in the individual case and finally on the surgeon's personal experience. If drainage is not employed it is necessary to observe the patient closely postoperatively and to remove any collection of fluid or air by thoracentesis. Some will not have to be aspirated at all, while others may need daily aspirations for a few days.

When tubes are employed, it has been found that a second small catheter (preferably mushroom in type) placed in an upper anterior intercostal space and used as an air vent, will lead to more certain, rapid, re-expansion. The lower tube should not be placed more posteriorly than the posterior axillary line, nor more dependently than the ninth intercostal space. Use of the eighth or seventh space is practicable. Absolute dependency, so necessary in the drainage of empyema, is not essential in these cases. The lower tube should not be a catheter but Standard Issue red rubber tubing, 1/4 inch I.D. by 1/16 inch wall (Catalogue No. 3878000). The end should be beveled and three or four holes cut in the

distal two to two and one-half inches. The skin should be drawn sharply upwards and a small stab incision made at right angles through the selected intercostal space. When the beveled end and 2 1/2 inches of the tube are pulled into the pleural cavity and the skin released, the intrapleural portion of the tube will tend to angle slightly upward. (Such passage of the tube also prevents ingress of air when the tube is removed.) The tube should then be pushed into contact with the parietal pleura and the tip of the bevel tacked with a fine suture so that the intrathoracic portion of the tube lies flat and without kinking along the parietal pleura. In those instances where it is inconvenient to so uture the tip of the catheter, it can be held in place by looping a suture over it and tieing it over a small bolster outside the skin. It is also wise when inserting the anterior catheter to place one skin suture which can be tied down at the time the tube is removed, thus preventing any ingress of air. In those instances in which penicillin is left within the chest, the posterior drain is clamped off for six to eight hours. (Figure 74).

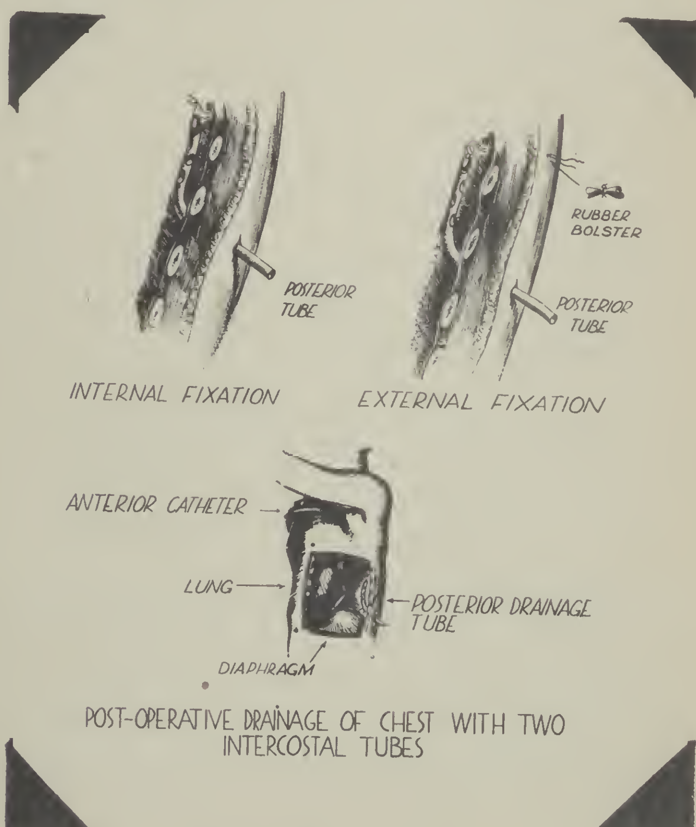

Figure 74 - See Text.

TRACHEOBRONCHIAL ASPIRATION ON THE OPERATING TABLE

It is our opinion that a very thorough aspiration of the trachea and major bronchi at the completion of the operation is a most important step in the surgical care of thoracic war wounds. All such patients have more or less blood or mucus in the air passages. The alert anesthetist periodically removes this during operation by inserting a small catheter through the endotracheal tube. At the completion of the operation, this is done with extreme care. The catheter is left in place as the endotracheal tube is withdrawn to remove as much as possible of any material that may have been missed previously or has gathered around the endotracheal tube. It must be recognized, however, that at best catheter aspiration through the tube is a blind procedure and no matter how much one turns the head or goes through other manipulations it is impossible to be certain that both main stem bronchi as well as the trachea have been aspirated. Anyone who has done lipiodal instillations of the bronchial tree with a catheter in the trachea and under floroscopic control, has experienced the difficulties sometimes encountered in passing a catheter into the left main bronchus. Also, catheter aspiration does not permit visual inspection of the air way to be certain that all such material has been removed. In instances where the patient has had more than a slight amount of such material during operation or has shown considerable "blast effect" of the lungs on the preoperative film, most of us have carried out a bronchoscopic aspiration as soon as the endotracheal tube was removed. We are aware that some are of the opinion that bronchoscopy is rarely indicated in this immediate postoperative period (9), but those of us who have had considerable experience in doing the actual surgery in the forward areas are strongly convinced that it is a most useful and very frequently indicated procedure. The objections raised by Beecher[9] are for the most part based, we feel, on misconceptions. The majority of us are of the opinion that it is not possible to clean completely the air way with a catheter. We have repeatedly bronchoscoped patients immediately after a very earnest attempt to do a careful aspiration with a catheter and have been amazed to find the amount of material that had been missed and often evidence showing that the left main bronchus had not been aspirated at all. Furthermore, if the anesthetist is alert, he can gauge the depth of the anesthesia so that the anesthesia need neither be prolonged nor deepened to permit bronchoscopy. All that is needed is that the jaws be kept separated and this must necessarily be done until the endotracheal tube is removed. It takes only two to three minutes from that point to the completion of the bronchoscopic aspiration so it does not seem warranted to classify this as either unduly prolonging or deepening the anesthesia. In actual practice, it is often possible for the anesthetist to do the bronchoscopy as the surgeon is finishing up, since there often are other wounds that have to be debrided and the bronchoscopy can be done concomitantly. It should also be pointed out that the patient should be in a light plane of anesthesia for this aspiration, as it is desirable that he cough from the stimulation of the aspirating tube. This will loosen material in the smaller bronchi and bring it within reach of the aspirator. If the patient does not cought during the procedure, he is too deeply anesthetized.

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Tracheobronchial Aspiration on the Operating Table, contd)

Another objection that has been raised to postoperative bronchoscopy is the slight risk to which the patients are subjected. It cannot be said that any procedure on the human body is without risk no matter what the operation. There have been two instances in this series where the patient died during bronchoscopy from what was apparently a "vagovagal" reflex. We have not known this to occur when the patient had been given a therapeutic dose of atropine within an hour. Inasmuch as atropine does theoretically protect against such accidents, it is advisable to administer atropine grains 1/100 intravenously 10 or 15 minutes before bronchoscopy, even though a preoperative dose of atropine has been given. It is our considered opinion that the slight risk engendered by postoperative bronchoscopic aspiration is more than offset by the benefits obtained. An extremely rare death from bronchoscopy is a dramatic and long remembered incident, while the common postoperative death from pulmonary complications is so frequent as to be disregarded. Although we are aware of the fact that the records are not accurate as to the number of times bronchoscopy was used immediately postoperatively, we do have records of its use in 436 cases but know that it was used in many more cases but not recorded. These were all thoracic, abdominal or thoraco-abdominal lesions. In this group there were two fatalities attributed to the bronchoscopy. This latter figure has been checked by a personal canvass of all the surgeons and anesthetists and we have been unable to find any other instances. Thus, it can be stated that the risk is approximately 0.4% or less, which seems perfectly justifiable in view of the high incidence of postoperative complications.

POSTOPERATIVE TREATMENT

The success of the operation, the degree of functional level to which the patient returns and the number and extent of complications with which the base section must contend, is dependent on the efficacy of the immediate postoperative treatment. The three prime objectives of the postoperative care are: Attainment of early, complete lung expansion; maintenance of a clear air way and thus the prevention of pulmonary complications; and relief of pain in order that the patient will maintain maximum respiratory excursions and be able to cough effectively. The details of management together with prevention and treatment of postoperative pulmonary complication is fully described in the section on postoperative care (page 65). Details of the treatment of abdominal postoperative complications in the thoraco-abdominal injuries are not presented here as they differ in no way from that of the usual abdominal lesion. In general it may be said that the postoperative course of the thoracolaparotomy with transdiaphragmatic repair is much smoother than the usual laparotomy, due to the decreased discomfort in the postoperative period and the lessening of abdominal distension. Severe wound infection or dehiscence of a thoracotomy is so uncommon as to be a rarity.

MORTALITY

In discussing the mortality in this group of 2267 thoracic and thoraco-abdominal cases, one must remember that the actual period of observation for all cases in this report is limited to the period of time that the patients were treated in the forward hospital. Thus, only matters pertaining to the initial treatment can be presented. Since preservation of life is the main objective of the forward surgeon, factors bearing on the mortality of this type of casualty are of prime importance. A series of tables has been prepared which considers the various factors influencing the mortality rate. Of the 1364 cases with penetrating or perforating wounds of the chest 135 died, a mortality of 9.89%. The 903 thoraco-abdominal wounds showed a mortality rate of 27.35% or 247 fatalities. The more salient points that have a bearing on the management of the thoracic and thoraco-abdominal wounds will be briefly discussed.

Thoracic Injuries

In assessing the value of any mortality figures, the severity of the wound is a most important item. This is an intangible factor varying with the judgment of the individual surgeon. The great majority of cases in this group were treated in Field Hospitals or in Evacuation Hospitals. These cases were for the most part "nontransportable" cases and as such represent the most severe type of thoracic wound reaching the forward hospital.

As might be expected, the mortality was higher for those having a thoracotomy as compared with those having only a simple debridement of the thoracic wall (Table XIV). The mortality figure was 6.90% in the 768 cases where debridement was done, as contrasted to 12.41% in the 435 cases of thoracotomy. Thus, the mortality for thoracotomy was almost twice that for simple debridement. A study of Table VIII shows the indications for thoracotomy in these cases. Traumatic thoracotomy was second only to thoraco-abdominal lesions as an indication for thoracotomy. In the traumatic thoracotomy group the thoracic wall and pulmonary damage was severe and the resultant derangement of the cardiorespiratory physiology so great that it is logical that this type of wound should have a high mortality. If we add this group to those thoracotomies done for questionable abdominal or mediastinal penetration, they comprise 70% of all thoracotomies. Thus in 70% of those with only intrathoracic injuries in which thoracotomy was performed there was an "absolute" indication for the performance of this operation. In 75 cases (17%) no indication for thoracotomy was noted on the record. It is only pure speculation to attempt to say how many of these cases did not have, what in the light of the experience of this Surgical Group, is considered as a "bona fide reason" for performing a thoracotomy. It is known to all of us that, in the early days, not a few needless thoracotomies were done. In view of the almost double mortality of thoracotomy over debridement it behooves the forward surgeon to think twice before performing such an operation in a forward hospital.

Initial Surgery of the Thorax and Thoraco-abdominal Wounds (Mortality, contd)

A study of the factors causing fatalities in the thoracic cases before May 1944, and after May 1944, is of interest. This date has been arbitrarily chosen for several reasons. By this time the policy for handling these injuries in the forward area had been crystalized in this Surgical Group. Furthermore, the employment of the surgical teams had gravitated from the Evacuation to the Field Hospitals. The Field Hospitals were usually employed (as far as the surgical teams in this Group were concerned) for the treatment on nontransportable cases. Also, by this time, the policy of evacuating thoracic cases from the Field Hospital to the Evacuation Hospital had been changed considerably. It had been shown that those cases in which the cardiorespiratory physiology had been stabilized could be safely transported to the Evacuation Hospital. Thus, only those thoracic cases which were not readily stabilized were kept in the Field Hospital. The late group were, accordingly, a much more severely wounded group than those treated before May 1944. Thus, one would expect an increase in the mortality rate in the post-May 1944 group. Actually, the reverse is true. Of the 400 cases treated in the pre-May 1944 group 45 died, a mortality of 11.27%. In the post-May 1944 group of 849 cases 71 died, a mortality of 8.3%. Thus, in spite of the fact that a more severe type of case was treated there was an improvement in the mortality rate of 2.9%. The factors involved in this improvement are: 1. A more physiological approach to the preoperative management; 2. A more complete understanding and a wider appreciation of the limited indications for early thoracotomy; 3. Improved postoperative care; 4. Adequate amounts of blood through the blood bank; 5. Better anesthesia, as the result of the widened experience of our anesthetists and more adequate anesthetic equipment (47); 6. Universal availability of penicillin for the seriously wounded. It is unfortunate that there is no numerical or quantitative standard that we can apply to the more severe type of case treated in the post-May 1944 group. Suffice it to say, that this mortality of 8.36% represents the death rate for the severest type of chest wound reaching the most forward hospital (Table XII).

The causes of death in the 116 cases that died in this series are tabulated according to frequency and day of death in Table XXI. There were nine cases that died on the operating table before the operation could be finished. Slightly over half (54.3%) of the fatalities occurred by the end of the second postoperative day and 91.3% of these that died did so on or before the seventh day following operation. Since there are 41 different causes of death they will be correlated in groups to simplify the discussion (Table XXII).

The largest and, from the clinical standpoint, most important group as they are amenable to treatment, are those that died of pathological conditions related to varying degrees of obstruction of the tracheobronchial tree. This group consists of 28 cases or 24.1% of the total deaths.

Seven of these were diagnosed as pulmonary edema occurring on the first to fourth postoperative days. The pathogenesis of pulmonary edema in persons with thoracic trauma, and the role of obstruction of the air way and the resultant anoxia so produced, has been previously discussed in this report. These cases represent a most difficult clinical problem in which the pulmonary damage is usually severe. It is not known whether positive pressure oxygen therapy, found by the authors to be beneficial in treating this type of pulmonary edema, was or was not employed as a therapeutic measure for cases in this group. We have seen, from what has been discussed above, that a patient not too severely wounded may recover from shock without complete relief of the tracheobronchial obstruction, or that there may be a recurrence of the obstructive process in the pulmonary tree. The latter sets the stage for the development of atelectasis and pneumonia. These complications arise in a manner similar to postoperative pulmonary complications in civilian life. The same etiological factors are present in both instances: An abnormal amount of fluid substances in the bronchial tree and conditions preventing the expulsion of this obstructing material. In the group of severe chest wounds it is not surprising that in 15 instances the cause of death was listed as "pneumonia" and in four cases "atelectasis". One other case died of tracheal obstruction due to mucus and in still another case the cause of death was listed simply as "wet lung" on the fifth postoperative day. Two cases, not included in the 2%, died due to aspiration of vomitus on the operating table. In the case of pneumonia the added factors of the exposure on the battlefield, pre-existing upper respiratory infection, the virulence of the organism and the resistence of the host are important factors. Infection flourishes in those parts of the lung with poor bronchial drainage. Therefore, the measures outlined earlier in this paper to improve tracheobronchial drainage are important not only during the resuscitation period to combat anoxia but also to prevent later atelectasis and, along with chemotherapy, to treat lobular and lobar pneumonia.

"Shock" was the next largest numerical group with 10 cases (8.6%). Eight of the 10 patients died on the operative day. The other two died, one each, on the day after and the second day following surgery. "Posttraumatic renal failure" was the next most important cause of death with nine cases (7.7%). This subject along with shock is considered in another section of this report (see page 759). It is important to remember, however, that this complication is a significant cause of death in severe thoracic wounds. The deaths due to heart injury are included in the separate section on heart lesions. Blast injury, six in all (3 pulmonary, 2 cerebral and 1 mediastinal) was the next most common cause of a fatal issue.

Intrapleural hemorrhage was the cause of death in six instances. This represents 5.2% of all the deaths but only 0.48% of the 1249 cases

with thoracic wounds in this series. In three cases, laceration of the aorta was present; in one a laceration of the vena cava; and in the other two the cause of death was stated simply as "intrapleural hemorrhage", of which one was probably from a laceration of the internal mammary vessels. This small number of deaths from intrapleural hemorrhage is a most important point when one considers how much intrapleural bleeding is stressed in the medical literature as a cause of death. These figures point out that death from intrapleural hemorrhage is not as common as we were led to believe. Therefore, great circumspection must be exercised before a thoracotomy is done solely for the cause. The criteria laid down earlier in this report for continued intrapleural hemorrhage should be considered carefully as they have proven of practical value in handling this large group of thoracic wounds.

Mediastinal infection was listed as the cause of death in three instances in two of which lacerations of the esophagus had been overlooked. Empyema was the cause of death in only one case in the forward hospitals, an incidence of 0.03%. Deaths due to pressure pneumothorax and severe laceration of the lung were recorded in only two instances. This indicates that considerable attention was paid to the mechanical aspects of stabilizing the cardiorespiratory physiology by the prompt employment of the measures previously described. Cerebral complications, other than anoxia, were present in two cases (one abscess and one embolus). In eight cases the causes of death were extrathoracic.

Cardiac Injuries

There were 30 deaths in the series of 75 cases. Three of the deaths occurred among the 18 cases of pericardial wounds and none was due to the pericardial involvement. Twenty-seven deaths occured among the 57 patients with myocardial lesions; of these 20 (35%) were due directly to the heart. The other seven were due to shock, severe thoraco-abdominal wounds, bronchopneumonia, esophageal wounds and anuria.

As would be expected, none of the contusions could have been helped by surgery. The largest group, again expected, which could have been benefitted by surgery, were those in which the chambers were penetrated. There were seven cases in which it is probable that successful repair of the defect would have saved the lives of those concerned. One perforating wound had been repaired successfully but died of acute myocardial insufficiency. There was extensive contusion of the myocardium in this case. The foreign body embolus to the heart has been described previously. Had the condition been recognized even a few days before death, removal of the fragment probably would have been life-saving. Harken[37] reported a similar but less marked area of contusion overlying an embolic foreign body to the right ventricle which was removed at operation. Referring to Table XXX, this is the case in which removal would have saved

life. The one case that might possibly have benefitted from surgery was also concerned with a foreign body. In this instance the missile was lying in a lacerated, contused wound of the right ventricle between the ventricle and sternum. The patient died suddenly and it is possible that removal of the foreign body might have reduced ectopic stimuli. Three cases of laceration and contusion would probably not have benefitted from surgery as the myocardial damage appeared to have been lethal and there was no conceivable repair that would have changed the fatal outcome. In two, for example, the lacerations and contusion had involved the anterior descending branch of the coronary artery and the vessel was thrombosed for at least half its length.

Thoraco-abdominal Injuries

For a comprehensive discussion of all statistics relating to the 903 cases of thoraco-abdominal injury, see section of "The Thoraco-abdominal Casualty" (page 566), and Tables XXXI through XLIII of the following appendix.

COMMENT

The group of cases here reported is large enough (2267) and treated over a sufficiently long period of time (two and one-half years) and over a variety of terrain (Tunisia, Sicily, Italy, Southern France and Germany) to have balanced a few of the variables and eliminated certain factors present in a smaller series in less diversified geographical locations. The cases here reported were all operated on in the forward hospitals where they could be held only long enough to become safely transportable. We, therefore, do not have sufficient later studies to be able to express any opinions except as they apply to the initial surgery of thoracic and thoraco-abdominal lesions. We do not believe that the available records are sufficiently adequate on which to base a statistical study. We do believe, however, that the combined opinions of those who have treated these cases are of significance. The following comments are made on the basis of our personal experience in treating these cases.

It has been to the delight of all that the Army Medical Department has been able to provide even the most forward surgical hospital with excellent equipment. The surgical instruments, roentgenographic and anesthetic apparatus approaches very closely that found in the better surgical clinics in civilian practice and has been found by us to be very adequate for the surgical treatment of traumatic lesions of the thorax and abdomen. With this equipment at hand and well trained and qualified personnel, there is no need for any slipshod or "foxhole" surgical procedures, even in the first-priority surgical hospital set up in conjunction with the divisional Clearing Station.

For the most part the fundamentals of thoracic war surgery are those of civilian thoracic surgical practice. There have been a few conceptions held over from the First World War that have been unsubstantiated by the experience in the present war. One of the most outstanding is the treatment of hemothorax. From the literature even of recent date (11), (39), (1), one would assume that hemothoraces during the early phase are best left alone (34), (40), unless of sufficient size to produce dyspnoea or else they should be aspirated and some of the fluid replaced with air. It has now been substantiated that there is no appreciable risk of starting up fresh bleeding by the aspiration of a hemothorax. The sooner and more completely the pleural space is evacuated, the smoother the course and the less likelihood of subsequent complications arising. It is now well established that there is no indication for the use of air replacement to check pulmonary hemorrhage as the severe hemorrhages are usually from a systemic vessel and the slightly increased intrapleural pressure is ineffective in stopping bleeding from one of these vessels. In fact, there are two definite contraindications to the use of air replacement in the early treatment of hemothorax. First is the inability to control the amount of pulmonary collapse for a sufficiently long period of time,

in many instances, because of the rapid evacuation of the patient. This has resulted in many patients arriving at the base with a collapsed lung. The second is that should empyema develop it is almost always total in extent thus making the problem of treatment much more complicated.

One of the more important concepts to come out of this war from a thoracic standpoint is the relative infrequency of indicated intrathoracic procedures. With the exception of the rare injuries to the mediastinal structures (heart, great vessels, trachea and major bronchi) there are very few indications for intrathoracic manipulations except as incidental maneuvers in spite of recent publications to the contrary (41). The great majority of surgical procedures within the chest are done because it is necessary to expose or enter the pleural cavity for some other reason such as an operation for a thoraco-abdominal injury or a traumatic thoracotomy. All have been surprised by the tremendous recuperative power of the lung. It was thought toward the end of World War I (29) and to a lesser extent recently (42) that in many cases with a large contusion or laceration of the lung, pulmonary resection was indicated. Our experience has been that the great majority of these lesions have been observed to resorb spontaneously and heal within a few weeks. Although there are at least theoretical indications for major resections we have found no fatal case in this series that we believe might have survived if a total lobectomy or pneumonectomy had been done. The one case that had a lobe resected died on the operating table.

Although it has been the practice in this Theater to debride <u>all</u> wounds (43), one still finds references in the recent literature (1), (44), to the advisability of not debriding chest wounds that are old or definitely infected. The reasons given have to do with the breaking down of the natural walls of resistance that have been set up and the fear of spreading the infection. We have not found this to be true and have treated old or infected wounds in exactly the same manner as the fresh ones. In fact, it is often necessary to do so in thoracic wounds and even carry out some type of plastic repair in order to effect an air-tight closure of a large thoracic wall defect.

We believe that the most dramatic improvement in any group of war wounds compared with the last war has been in the thoraco-abdominal group. The startling reduction in mortality from 60% to 70% (46) has been reduced to approximately that for straight abdomens (20% to 25%). Such results were made possible largely by the advances in thoracic and abdominal surgery in the period between the wars. It was possible for the surgeon to enter this war with a well grounded understanding of the physiology of the cardiorespiratory system. This knowledge together with skillful anesthesia by a well trained anesthetist using modern anesthetic apparatus allowed the surgeon to work unhurriedly and safely through the open thorax for as long as was necessary to accomplish his purpose. Experience in the transdiaphragmatic resections of the lower

esophagus and upper portion of the stomach pointed the way to transdiaphragmatic thoraco-abdominal repair. This transthoracic approach plus the realization by the surgeon of the necessity of correcting thoracic physiology first in those cases in which a laparotomy had to be done has resulted in a very acceptable mortality rate for this severely wounded group.

It would seem to be amiss if some mention was not made in this report of the employment of thoracic surgical teams on the basis of the experience gained in their use in this Theater. During war ideal conditions usually are not obtainable. There will never be enough well qualified thoracic surgeons to have a sufficient number in every medical installation. In order to use these that are available most efficiently, they should be able to devote their full time to the care of thoracic casualties. This was not possible for most of us during the period of this report. By the use of a first priority surgical hospital it is possible to concentrate the severely wounded in these installations with the least possible delay as outlined previously. Although it is possible to evacuate the majority of the thoracic cases to an Evacuation Hospital directly from the Clearing Station or after resuscitative procedures have been done at the Field Hospital (average of 57% in one nine-month period) it is still necessary to retain some severe thoracic casualties and those with thoraco-abdominal lesions. During periods of heavy activity, it is not possible for one thoracic team to care for all thoracic and thoraco-abdominal cases in a platoon of a Field Hospital. It is suggested that should the necessity arise in the future it would be wise to place with each platoon one senior thoracic surgeon who would have two teams under his direction. In this way the one thoracic surgeon would be able to supervise the care of all serious thoracic and thoraco-abdominal casualties. The load of thoracic cases will fall on the Evacuation Hospital from a numerical standpoint and there will be also a certain proportion of those who are severely wounded. In an Evacuation Hospital it is important for a well trained thoracic surgeon to be a member of the staff. While he cannot operate on all the cases himself he should have supervisory control and be able to establish the principles upon which all thoracic cases are treated. An integral part of the plan should be a thoracic surgical center in the base section set as close up to the Evacuation Hospitals as possible. It has been well established that the concentration of thoracic cases in a minimum of institutions where their care can be under the supervision of a thoracic surgeon is of utmost importance.

SUMMARY AND CONCLUSIONS

1. Two thousand two hundred sixty-seven thoracic wounds, including 903 thoraco-abdominal injuries are presented whose initial surgery in the forward areas during the campaigns in Tunisia, Sicily, Italy, Southern France, Rhineland and Central Europe, was carried out by the surgical teams of the 2nd Auxiliary Surgical Group. For penetrating or

perforating wounds of the thorax without penetration of the diaphragm the mortality was 9.89%. The thoraco-abdominal lesions showed a mortality of 27.35%.

2. Restoration of cardiorespiratory balance is the most important factor in the resuscitation of the thoracic casualty. When in cardiorespiratory balance, many cases with thoracic injuries (except thoraco-abdominal lesions) can be safely evacuated to an Evacuation Hospital for surgery, thus relieving the load on the forward, first-priority surgical hospital. Thoracentesis (without air replacement), intercostal nerve block or tracheobronchial catheter aspiration all may be indicated in addition to replacement therapy by blood in restoring the thoracic casualty to an improved physiological state. The time interval from injury to operation is not as important as the time from injury to stabilization and the conçomitant banishment of anoxia.

3. The aim of the forward surgeon doing initial surgery on thoracic patients is the saving of life first, and the prevention and control of infection second.

4. We believe the following to be the indications for thoracotomy in the forward area: 1. Possible thoraco-abdominal injuries; 2. Large chest wall defects (traumatic thoracotomies); 3. Miscellaneous indications, (a) suspected injury to the heart that might be amenable to repair, (b) continuing severe intrapleural hemorrhage, (c) possible esophageal damage, (d) large bronchial fistulae from injury to the trachea or a major bronchus, (e) removal of excessively large intrapleural or intrapulmonary foreign bodies (such foreign bodies will in most instances have produced a traumatic thoracotomy in transversing the thoracic wall).

Thoracotomy in the forward area for other than these definite indications is strongly condemned.

5. Thoraco-abdominal injuries (proven or suspected) is the most frequent indication for thoracotomy in the early treatment. For those demanding laparotomy, the cardiorespiratory system should be stabilized first even if this necessitates a thoracotomy (prior to the laparotomy) The advantages of each approach have been presented. In this series of cases the transdiaphragmatic approach has been employed more frequently than laparotomy alone.

6. Large chest wall defects (pleural opening of 6 cm. or greater following debridement) frequently must be treated in the forward hospitals as they often cannot be completely resuscitated and brought into cardiorespiratory balance without surgical repair of the wound. Such cases have been termed "traumatic thoracotomies" as debridement of the wound gives adequate exposure for any indicated intrathoracic procedure.

Initial Surgery in Thorax and Thoraco-abdominal wounds (Summary and Conclusions, contd)

7. Endotracheal anesthesia by a skillful (preferably physician) anesthetist using modern anesthesia apparatus is of utmost importance. Major intrathoracic or transthoracic procedures are better avoided in the absence of such.

8. Early, complete pulmonary expansion is the prerequisite of an uncomplicated postoperative convalescence, and is the best insurance against the development of subsequent empyema and clotted hemothorax.

9. Maintenance of a clear airway by whatever means that are necessary is essential during the preoperative, operative and postoperative periods. Tracheobronchial aspiration with a catheter or by bronchoscopy is strongly advocated whenever the patient is unable to accomplish this by coughing.

10. Suggestions are presented for the efficient and effective use of thoracic surgical teams in treating thoracic casualties in the forward area.

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THORACIC AND THORACO-ABDOMINAL WOUNDS

STATISTICAL APPENDIX

STATISTICAL APPENDIX

Introduction.

This statistical appendix has been compiled to assemble in tabular form all the available information from the records of the cases herein reported. The figures mentioned in the body of the report are the ones that we feel to be significant and reliable. We do not believe that many of the remainder are of statistical significance. They are all included in this appendix for the sake of completeness and are merely being presented as figures with no attempt at interpretation. Whenever the figures have not supported the opinion of the surgeons doing the cases, we have disregarded the figures.

We feel that the records, from which the figures were derived, are surprisingly complete when one considers the conditions under which they were originally prepared. It was necessary for each team to prepare from four to seven forms or records on each case. Each record necessarily contained much duplicated information. All these records had to be prepared in longhand with no secretarial or stenographic help. Also, all postmorten examinations had to be done by the team members and the report written in longhand. During rush periods when the teams were working long hours under very adverse circumstances, one could not expect much zeal in the preparation of duplicate records for some future study. The most amazing thing is that the records were prepared at all.

The experience of this Surgical Group in treating priority thoracic and thoraco-abdominal wounds in the forward area has been very extensive and the authors sincerely wish that the data presented was commensurate with this extensive practice. We do believe, however, that the compilation of this large series of war wounds involving the thorax, incomplete as it may be, is somewhat unique and we are not aware of any similar study having been presented. It seems wise, therefore, to present all the data obtainable from the records as it is impossible to know at this date what may be of future importance.

It should be noted that civilians and prisoners of war have been eliminated from the tables dealing with thoracic injuries, except for the one table showing the overall experience of the Group. All other figures refer to American soldiers only. It was not feasible to so separate this group in the thoraco-abdominal series. The figures in the latter group include all cases done by the various teams.

Percentages appear in many tables based on a comparatively few cases. These figures are included for completeness, but cannot be considered accurate.

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Table of Contents of Statistical Appendix (Thoraco-Abdominal Wounds, contd).

Statistical Appendix.

TABLE I

Summary of Total Cases

	Chest	Thoraco-abdominal	Total
Cases	1364	903	2267
Deaths	135	247	387
Percent Mortality	9.89%	27.35%	17.07%

Summary of all cases, penetrating and perforating chest and thoraco-abdominal, treated by this Group, and the mortality rates for each group.

TABLES OF THE PENETRATING AND PERFORATING CHEST WOUNDS

TABLE II

Type of Chest Wound

		Prior 1 May 1944		Post 1 May 1944		Total
		G.S.*	T.S.*	G.S.*	T.S.*	
Total U.S. Cases		243	157	623	226	1249
Chest Main Wound		233	147	529	203	1112
Percent		95.88%	93.57%	84.91%	89.82%	89.02%
Side involved	R	96	85	301	117	602
	L	134	67	296	101	603
Bilateral		2	5	20	8	35
Percent of total cases	R	39.50%	54.14%	48.31%	51.77%	48.19%
	L	55.14%	42.67%	47.51%	44.69%	48.27%
Bilateral		0.82%	3.18%	3.21%	3.57%	2.88%
Type Wound	Pen	170	105	310	134	719
	Perf	62	49	284	83	478
	Lac	4	3	26	8	41
Percent of total cases	Pen	69.96%	66.88%	49.76%	59.29%	57.56%
	Perf	25.51%	31.21%	45.58%	36.99%	38.27%
	Lac	1.65%	1.91%	4.17%	3.57%	3.28%
Agent	S.F.	183	119	389	139	830
	G.S.W.	49	35	207	80	371
	Stab	2				2

Records the wounding agent, side of chest involved, and type of wound in American battle casualties.

*G.S.-General Surgical Teams.
*T.S.-Thoracic Surgical Teams.

Statistical Appendix, cont'd.

TABLE III

Preoperative Treatment

		Prior 1 May 1944	Post 1 May 1944	Total
U.S. Cases		400	849	1249
Shock	None	149	314	463
	Mild	67	162	229
	Moderate	83	190	273
	Severe	44	110	154
	Not recorded	57	71	128
Blood	Cases	172	633	805
	Total cc given	179900	753850	933750
	Av cc per case	1046	1189	1160
	Largest Amt given	3600	7500	7500
Plasma	Cases	196	569	765
	Total cc given	138200	351200	489400
	Av cc per case	705	617	640
	Largest Amt given	2500	2750	2750
Autotrans-fusion	Cases	29	42	71
	Total cc given	23400	28950	52350
	Av cc per case	807	689	737
	Largest Amt given	2700	2000	2700
Morphine	Over $\frac{1}{2}$ grain	56	98	154
	1 grain and over	9	8	17
Average time lag in hours		15.7	14.0	14.5

This table shows the preoperative (shock) treatment in American battle casualties. It included all treatment recorded on the Emergency Medical Tag, plus the resuscitative measures in the form of blood and/or plasma used in the hospital of initial surgery from time of admission to the end of operation. Only those records where a definite amount of the material was indicated, were used in this tabulation. Many more cases than is apparent from this table, received such therapy but as no definite record was made of the amount, they were not included.

Statistical Appendix, cont'd.

TABLE IV

Preoperative Thoracic Procedures

		Prior 1 May 1944	Post 1 May 1944	Total
U. S. Cases		400	849	1249
Intercostal block		8	69	77
Thoracentesis		52	209	261
Thoracentesis via intercostal catheter		1	9	10
Treated pressure-pneumothorax		1	10	11
Tracheal Aspiration	Catheter	4	25	29
	Bronchoscope	0	8	8

Lists additional preoperative resuscitative measures.

TABLE V

Anesthetic Agents

		Prior 1 May 1944		Post 1 May 1944		Total
		G.S.*	T.S.*	G.S.*	T.S.*	
Agent	Ether	86	53	96	72	307
	Pentothal	30	34	15	29	108
	Gas-oxygen-ether	73	39	455	106	673
	Gas-oxygen			1		1
	Novocain	37	19	44	21	121
	GOE-pentothal	1				1
	Ether-pentothal		2			2
	Novocain-pentothal		1			1
	Spinal-procaine	1				1
	Brachial Block		1			1
TOTAL		228	149	611	228	1216
Type inhalation	Endotracheal	92	91	520	159	862
	Open	43	6	6	1	56
	Mask	20	2	9	2	33
TOTAL		155	99	535	162	951

Indicates the various anesthetic agents used and the method of administration.

*G.S.-General Surgical Teams.
*T.S.-Thoracic Surgical Teams.

Statistical Appendix, cont'd.

TABLE VI

Incidence of Anesthetic Agents

			Prior 1 May 1944	Post 1 May 1944	Total
	Total anesthetics recorded		377	839	1216
Agent	Ether	Cases	139	168	307
		Percent	36.87%	20.02%	25.25%
	G.O.E.	Cases	112	561	673
		Percent	29.71%	66.86%	56.17%
	Novocain	Cases	56	65	121
		Percent	14.85%	7.74%	9.95%
	Pentothal	Cases	64	44	108
		Percent	16.98%	8.39%	8.88%
	Ether Pentothal	Cases	2	0	2
		Percent	0.53%	0.00%	0.16%
	G.O.E. Pentothal	Cases	1	0	1
		Percent	0.28%	0.00%	0.09%
	Novocain Pentothal	Cases	1	0	1
		Percent	0.28%	0.00%	0.09%
	Gas-oxygen	Cases	0	1	1
		Percent	0.00%	0.12%	0.09%
	Brachial Block	Cases	1	0	1
		Percent	0.28%	0.00%	0.09%
	Spinal Procaine	Cases	1	0	1
		Percent	0.28%	0.00%	0.09%
Type inhalation	Endotracheal	Cases	183	679	862
		Percent	48.54%	80.93%	70.88%
	Open	Cases	49	7	56
		Percent	12.99%	0.83%	4.60%
	Mask	Cases	22	11	33
		Percent	5.83%	1.31%	2.71%

Indicates the various anesthetic agents used, the method of the administration of those agents, and the relative percentages of the total number of anesthetics given.

Statistical Appendix.

TABLE VII

Chest Wall Debridement and Associated Major Wounds

		Prior 1 May 1944 G.S.*	Prior 1 May 1944 T.S**	Post 1 May 1944 G.S.*	Post 1 May 1944 T.S**	Total
Total cases		243	157	623	226	1249
Debridements chest wall only		160	74	385	149	768
Percent of total cases that are debridements		65.84%	47.13%	61.79%	65.93%	61.49%
Deaths		17	2	24	10	53
Mortality		10.63%	2.70%	6.23%	6.71%	6.90%
ASSOCIATED MAJOR WOUNDS	Abdomen	10		29	6	45
	Severe compound fract	9	4	19	8	40
	Transverse myelitis	5	2	11	5	23
	Negative abdominal exploration	6	1	2		9
	Severe soft tissue wound	4		5	3	12
	Amputation	1		1	2	4
	Lacerated kidney	1		1		2
	Brachial plexus		2	1	1	4
	Trench foot		1		1	2
	Tracheal (cervical)			2		2
	Major vessel			4	2	6
	Peripheral nerve			3		3
	Cerebral blast			4		4
	Contralateral thoraco-abdominal			4		4
	Perforated pharynx			1		1
	Severe pulmonary blast			3	2	5
	Compound fracture cervical spine			1		1
	Compound fracture skull			1		1
Total associated major injuries in debridements		36	10	92	30	168
Percent of debridements that had associated major injuries		22.50%	13.51%	23.89%	20.13%	21.86%

Shows the number of cases where chest wall debridement only was done. Associated major injuries are tabulated.

*G.S. - General Surgical Team. **T.S.-Thoracic Surgical Teams.

Statistical Appendix, contd.

TABLE VIII

Types of Thoracotomy and Indications

		Prior 1 May 1944 G.S.*	Prior 1 May 1944 T.S.**	Post 1 May 1944 G.S.*	Post 1 May 1944 T.S.**	Total
Total U.S. cases		243	157	623	226	1249
Thoracotomies		67	72	224	72	435
Percentage Thoracotomies		27.57%	45.86%	35.95%	31.86%	34.83%
Deaths		11	10	27	6	54
Mortality		16.42%	13.88%	12.05%	8.33%	12.41%
Thoracotomy	Through Wound	55	61	194	58	368
	Separate incision	12	11	30	14	67
Type	Rib resection	57	58	188	62	365
	Intercostal	3	9	20	9	41
Recorded Indications for the thoracotomies	Traumatic	15	34	77	30	156
	? thoraco-abdominal	16	12	65	29	122
	?Bleeding	7	12	11	6	36
	Injury to mediastinum and/or heart	2	1	16	1	20
	Foreign body	1	7***	3	0	11
	Lung laceration	1	0	2	0	3
	Bone fragments	0	2	1	0	3
	Bronchial fistula	0	1	2	0	3
	? esophagus	0	0	1	2	3
	? hilar vessel	0	0	1	0	1
	Pressure pneumothorax	0	0	1	0	1
	Unexpanded lung	0	0	1	0	1
	Indication not recorded	27	0	44	4	75

Reveals the statistical data available for those cases where a thoracotomy was performed.

*G.S. - General Surgical Team.
**T.S. - Thoracic Surgical Team.
***7 - Three removed.

Statistical Appendix. contd.

TABLE IX

Associated Major Wounds

		Prior 1 May 1944 G.S.*	Prior 1 May 1944 T.S.**	Post 1 May 1944 G.S*	Post 1 May 1944 T.S.**	Total
Total U.S. Cases		243	157	623	226	1249
Chest alone, or associated with minor wounds		201	141	514	193	1049
Total Associated major wounds		42	16	109	33	200
	Abdomen	13	2	41	7	63
	Severe compound frac.	9	4	25	4	42
	Transverse myelitis	10	5	14	10	39
	Amputation	1	0	3	3	7
	Severe soft tissue	5	0	7	3	15
ASSOC	Brachial plexus	1	2	1	1	5
IATED	Peripheral nerves	0	0	3	0	3
MAJOR	Major vessels	0	0	3	1	4
WOUNDS	Lacerated kidney	0	0	1	0	1
	Negative abdominal exploration	2	0	0	0	2
	Severe retroperitoneal hematoma	1	0	0	0	1
	Penetrating eyes	0	1	0	0	1
	Trachea	0	1	2	1	4
	Trench Foot	0	1	0	1	2
	Gas infection	0	0	1	0	1
	Contralateral thoraco-abdominal	0	0	4	0	4
	Perforated pharynx	0	0	1	0	1
	Cerebral blast	0	0	2	0	2
	Compound fracture cervical spine	0	0	1	0	1
	Fractured skull	0	0	0	1	1
	Pulmonary blast	0	0	0	1	1
Deaths in Associated Major wounds		***12	1	25	8	46
Mortality		28.57%	6.25%	22.94%	24.24%	23.00%

Indicates the detailed analyses of the associated major wounds. In this group, we have included spinal cord lesions even though the chest

*G.S. - General Surgical Teams. **T.S. Thoracic Surgical Teams.

***12 - One before operation completed.

Statistical Appendix. Table IX, contd.

wound was the major wound, for it is our opinion that the cord injury, anatomic or physiologic, is the major lesion.

TABLE X

Intrathoracic Operative Findings

	Prior 1 May 1944	Post 1 May 1944	Total
Bleeding intercostal vessels	31	22	53
Bleeding internal mammary vessels	4	8	12
Pericardium and/or heart injured	7	28	35
Injured esophagus	0	3	3

Demonstrates the incidence of intrapleural bleeding noted at operation.

TABLE XI

Operative Technical Procedures

		Prior 1 May 1944	Post 1 May 1944	Total
Pleural Lavage		39	134	173
Pleural Drainage		97	229	326
Tracheal aspiration	Catheter	36	52	88
	Bronchoscopy	57	212	269

Shows the incidence of the various technical procedures instituted at close of the operation. These are the recorded instances only, and represents only a fraction of the actual number of times these procedures were employed. By 1 May 1944, tracheo-bronchial toilet was an accepted routine in every endotracheal anesthetic, and thus was not recorded in all instances.

Statistical Appendix.

TABLE XII

Gross Mortality Rate

		Prior 1 May 1944	Post 1 May 1944	Total
Total Cases		408	956	1364
Civilians and P.O.W.'s		8	107	115
Total American casualties		400	849	1249
Deaths	Civilian and POW	2	17	19
	U.S.	45	71	116
	Total	47	88	135
Mortality	Civilian and POW	25%	15.89%	16.52%
	U.S.	11.25%	8.36%	9.21%
	Total	11.52%	9.20%	9.89%
Chest the main wound. (U.S. cases)	Cases	380	732	1112
	Deaths	32	38	70
	Mortality	8.42%	5.19%	6.29%
Chest not the main wound. (U.S. cases)	Cases	20	117	137
	Deaths	13	33	46
	Mortality	65.00%	28.20%	33.58%

Summary of mortality for all groups of cases, divided into two periods, prior 1 May 1944 and post 1 May 1944, and including all cases seen during the entire period this group was active.

Statistical Appendix. contd.

TABLE XIII

Operative Mortality-A

&

		General Surgical Team	Thoracic Surgical Team	Total
Total Cases		952	412	1364
Civilians and P.O.W.'s		86	29	115
Total U.S. Casualties		866	383	1249
Deaths	Civilian & POW	17	2	19
	U.S.	87	29	116
Mortality	Civilian & POW	19.88%	6.89%	16.52%
	U.S.	10.05%	7.57%	9.21%
Debridements	Cases	545	223	768
	Deaths	41	12	53
	Mortality	7.52%	5.38%	6.90%
Thoracotomies	Cases	291	144	435
	Deaths	38	16	54
	Mortality	13.06%	11.11%	12.41%
Associated major wounds	Cases	151	49	200
	Deaths	37*	9	46
	Mortality	24.50%	18.37%	23.00%
Autopsy	Yes	54	24	78**
	No.	33	3	38

Demonstrates the results and mortality rate for all cases during the entire period this group was active, but separated as to General Surgical teams and Thoracic Surgical teams. There were 27 General Surgical teams and four Thoracic Surgical teams.

*37 - One before operation completed.
**78 - (67.7%)

Statistical Appendix. (contd)

TABLE XIV

Operative Mortality - B

		Prior 1 May 1944	Post 1 May 1944	Total
Debridements	Cases	234	534	768
	Deaths	19	34	53
	Mortality	8.12%	6.35%	6.90%
Thoracotomies	Cases	139	296	435
	Deaths	21	33	54
	Mortality	15.11%	11.15%	12.41%
Associated major wounds	Cases	58	142	200
	Deaths	13*	33	46
	Mortality	22.41%	23.24%	23.00%

Similar to Table XIII, but cases divided into the two time periods. Calculated for U.S. Casualties only.

*13 - One preoperative.

TABLE XV

Component Mortality

		Prior 1 May 1944		Post 1 May 1944		Total
		G.S.*	T.S.**	G.S.	T.S.	
Total cases		248	160	704	252	1364
Civilians and P.O.W.'s		5	3	81	26	115
Total U.S. Cases		243	157	623	226	1249
Deaths	All	33	14	71	17	135
	U.S.	32	13	55	16	116
	Civilians & POW's	1	1	16	1	19
Mortality	All	13.30%	8.75%	10.09%	6.74%	9.89%
	U.S.	13.17%	8.28%	8.82%	7.08%	9.21%
	Civilians & POW's	20.00%	33.33%	19.75%	3.85%	16.52%

Classifies the cases as to type of case, operated by General Surgical Team (G.S.) or Thoracic Surgical Team (T.S.) plus the additional break down in Prior and Post 1 May 1944.

*G.S. - General Surgical Team.
**T.S.-Thoracic Surgical Team.

Statistical Appendix. (contd)

TABLE XVI

Overall Deaths

	Prior 1 May 1944 G.S.*	Prior 1 May 1944 T.S.**	Post 1 May 1944 G.S.	Post 1 May 1944 T.S.	Total
Total U.S. Cases	243	157	623	226	1249
Total U.S. Deaths	32	13	55	16	116
Mortality	13.17%	8.28%	8.82%	7.08%	9.21%
Chest Main Wound	21	11	30	8	70
Percent	65.62%	84.61%	54.54%	50.00%	60.34%
Associated Major Wounds	12***	1	25	8	46
Percent	34.38%	15.39%	46.46%	50.00%	39.66%
Deaths Following Thoracotomy	11	10	27	6	54
Percent	34.37%	76.91%	46.55%	35.29%	46.54%
Preoperative Deaths (includes thosewhere operation not completed.	3	1	4	1	9
Percent	9.37%	7.69%	7.27%	5.88%	7.76%
Post Traumatic Uremic Syndrome	0	0	6	3	9
Percent	0	0	10.34%	17.65%	12.00%
Incidence of Post Traumatic Uremia	0	0	0.96%	1.33%	1.06%****

Table of overall deaths showing breakdown into major groups.

*G.S. - General Surgical Team.
**T.S. - Thoracic Surgical Team.
***12- One before operation completed.
****1.06% - This figure is calculated on basis of Post 1 May 1944 only, since no cases were recognized as such in the Prior 1 May 1944 group.

Statistical Appendix. (contd)

TABLE XVII

Deaths in Thoracotomies

		Prior 1 May 1944 G.S*	Prior 1 May 1944 T.S**	Post 1 May 1944 G.S.	Post 1 May 1944 T.S.	Total
Total U.S. Cases		243	157	623	226	1249
Deaths following thoracotomy		11	10	27	6	54
Indications recorded for thoracotomies in those that died.	Traumatic	5	4	8	1	18
	?Thoraco-abdominal	4	1	6	2	13
	?Bleeding		4	1	1	6
	?Heart lesion		1	1		2
	?Esophageal lesion			1	1	2
	Lacerated lung			1		1
	Major vessel injury			1		1
	Bronchial fistula			1		1
	Bone fragments			1		1
	Not recorded	2		6		8

*G.S. - General Surgical Team.
**T.S. - Thoracic Surgical Team.

Statistical Appendix. (contd)

TABLE XVIII

Deaths in Associated Major Wounds

Breakdown of Deaths in Associated Major Wounds	Prior 1 May 1944 G.S.*	Prior 1 May 1944 T.S.**	Post 1 May 1944 G.S.	Post 1 May 1944 T.S.	Total
Total U.S. Cases	243	157	623	226	1249
Deaths in associated major wounds	12	1	25	8	46
Abdomen	6		13	3	22
Transverse Myelitis	2	1	5	4	12
Amputation			2	1	3
Severe Fracture Compound comminuted	2		1		3
Negative Abdominal exploration	1***				1
Severe soft tissue injury	1				1
Major vessel injury			1		1
Lacerated kidney not involving peritoneum or diaphragm			1		1
Thoraco-abdominal on contralateral side			1		1
Overlooked esophageal injury			1		1

*GS - General Surgical Team.
**TS - Thoracic Surgical Team.
***1 - Retroperitoneal hematoma.

Statistical Appendix. (contd)

TABLE XIX

Postmortem Findings

Postmortem findings as recorded	Prior 1 May 1944 G.S.*	T.S.**	Post 1 May 1944 G.S.	T.S.	Total
Gas infection	2	1	1		4
Aspirated vomitus	1				1
Pulmonary embolus	2	1			3
Pressure pneumothorax	1				1
Massive mediastinal hemorrhage		1			1
Empyema and brain abscess			1		1
Massive intrapulmonary hemorrhage			1		1
Massive pulmonary collapse			1		1
Cerebral emboli			1		1
Multiple cerebral thrombosis and encephalomalacia			1		1
Thrombosis pulmonary artery			1		1
Severe pulmonary blast			1		1
Cardiac failure (heart had been sutured)			1		1
Vago-vagal reflex			1		1
Cerebral blast				1	1
Cardiac standstill during operative and postoperative decerebrate rigidity syndrome.				1	1

*G.S. - General Surgical Team.
**T.S. - Thoracic Surgical Team.

TABLE XX

Overlooked Thoracic Injuries Found at Postmortem

Overlooked Injuries	Prior 1 May 1944 G.S.*	T.S.**	Post 1 May 1944 G.S.	T.S.	Total
Esophagus		1	1		2
Heart	1		3	1	5
Perforated aorta			2	1	3
Trachea			1		1
Trachea and esophagus			1		1
Vena cava			1		1
Heart with massive pulmonary collapse			1		1

G.S.* - General Surgical Team. T.S.** - Thoracic Surgical Team.

TABLE XXI

Causes of Death

Cause	Before Op Comp	Op Day	1	2	3	4	5	6	7	8	9	10	12	13	Tot	Per-cent
			Postoperative Day *													
Pneumonia			2	1	1	1	3	1	1	2		2			14	12.1
Shock	1	7	1	1											10	8.6
Post-traumatic uremia						3	2	1	3						9	7.7
Pulmonary edema			1	1	3	2									7	6.0
Atelectasis		3	1												4	3.4
Pulmonary embolus			2									1		1	4	3.4
Gas Gangrene (2 Thoracic wall)					1	1	1								3	2.6
Cerebral anoxia		2					1								3	2.6
Lacerated aorta	1	2													3	2.6
Overlooked cardiac injury	1		2												3	2.6
Pulmonary blast			2	1											3	2.6
Mediastinitis (overlooked injury to esophagus)							1			1					2	1.7
Cardiac fibrillation		2													2	1.7
Cerebral blast				1							1				2	1.7
Massive intrapulmonary hemorrhage		1		1											2	1.7
Aspirated vomitus (anes.)	1			1											2	1.7
Massive intrapleural hemorrhage		1	1												2	1.7
Cardiac injury	1	1													2	1.7
Severe lung laceration	1														1	0.9
Cerebral malaria					1										1	0.9
Vago-vagal refles	1														1	0.9
Mediastinal hemorrhage			1												1	0.9
Cerebral embolus					1										1	0.9
Peritonitis				1											1	0.9
Pulmonary artery thrombosis			1												1	0.9
Overlooked injury to esophagus and trachea					1										1	0.9
"Wet" lung							1								1	0.9
Brain abscess													1		1	0.9
Empyema									1						1	0.9
Cardiac tamponade		1													1	0.9
Severe phosphorus burns								1							1	0.9
Extensive wounds					1										1	0.9
Lacerated vena cava		1													1	0.9
Mediastinal blast			1												1	0.9
Atelectasis and cardiac injury		1													1	0.9
Asphyxiation (trachial obstruction)			1												1	0.9
Pneumonia and anaerobic infection									1						1	0.9
Right heart failure						1									1	0.9
Massive emphysema		1													1	0.9
Pressure pneumothorax			1												1	0.9
Spleno-hepatomegaly and jaundice											1				1	0.9
Not recorded	2	3	2	1	2	3	2		1						16	13.8
Totals	9	26	19	9	11	11	11	3	7	3	2	3	1	1	116	
Percent	7.8	22.4	16.4	7.7	9.5	9.5	9.5	2.6	6.0	2.6	1.7	2.6	0.9	0.9		100%

* No deaths recorded on 11th postoperative day.

Statistical Appendix. (Table XXI, contd)

Lists the recorded causes of death and the incidence of deaths with relation to cause and postoperative day.

TABLE XXII

Grouped Causes of Death

	Cause	Cases	Percentage of Deaths
Total Deaths		116	1 00%
Related to Tracheo-bronchial obstruction	Pneumonia	15	12.93%
	Pulmonary edema	7	6.03%
	Atelectasis	4	3.45%
	Asphyxiation	1	0.86
	"Wet Lung"	1	0.86%
Total related to tracheo-bronchial obstruction		28	24.14%
	Shook	10	8.62%
	Post-traumatic uremia	9	7.76%
	Extra thoracic	8	6.89%
	Cardiac (including one tamponade	9	7.76%
	Blast	6	5.17%
	Intrapleural hemorrhage	6	5.17%
Cerebral Complications	Anoxic	3	2.58%
	Non-anoxic	2	1.72%
	Pulmonary embolus	4	3.45%
	Mediastinitis	3	2.58%
	Bronchial fistula	2	1.72%
	Empyema	1	0.86%
	Miscellaneous	9	7.76%
	Not recorded	16	13.79%

HEART AND PERICARDIUM

Statistical Appendix. (contd)

TABLE XXIII

Signs and Symptoms of Cardiac Lesions

Suspicion from course of missile	22
X-ray evidence:	
Foreign body in region of heart (four labeled fuzzy or double-contoured)	8
Alteration, size and shape of cardiac shadow	5
Foreign body suspected in region of heart, not proved	2
Symptoms due to anoxia:	
Dyspnea	6
Necessity for continuing oxygen	6
Mental confusion or semi-stupor	5
Cyanosis	3
Signs suggestive of cardiac dysfunction:	
Persisting tachycardia (120 or above)	8
Arrhythmia (transient fibrillation 1; extra systoles 6;)	7
Bradycardia (below 65)	2
Apical systolic murmur	2
Friction rub, precordial	2
Paradoxical pulse	1
Nausea and vomiting	1
Cardiac tamponade	5
(recognized clinically 3)	
(suspected 1)	

This table is a compilation of the number of times that each sign or symptom was noted in proven cardiac cases. In a few cases the findings were noted on the records but were not appreciated until after the cardiac lesion had been discovered at operation or autopsy.

Statistical Appendix. (contd)

TABLE XXIV

Type of Cardiac Wound

Anatomical Portion Involved		Contusion	Pure Laceration	Laceration & Contusion	Perforated Chamber	Embolus to Heart	Total
Ventricle	Left	7	7	5	7	0	26
	Right	5	2	2	3	2	14
	Both	3	0	2	0	0	5
Auricle	Left	0	0	0	2	0	2
	Right	1	1	0	7	0	9
Right auricle and ventricle		0	0	1	0	0	1
Total Lesions		16	10	10	19	2	57
Deaths	Total	11	1	5	9	1	27
	Due to heart	6	1	4	8	1	20
Mortality Rate	Total	68.7%	10.0%	50.0%	46.8%	50.0%	47.4%
	Due to heart	37.5%	10.0%	40.0%	42.1%	50.0%	35.1%

Lists the types of lesions occurring in the various anatomical portions of the heart. Mortality rates are calculated for deaths considered due to the heart directly.

Statistical Appendix. contd.

TABLE XXV

Deaths in Cardiac Lesions

Lesion		Ventricle Left	Ventricle Right	Ventricle Both	Auricle Left	Auricle Right	Right Auricle and Ventricle	Total
Contusion	Total	4	4	2	0	1	0	11
	Due to Heart	3	2	1	0	0	0	6
	Type of death due to heart	(c,c,x)	(c, x)	(x)				(6)
	Percent of death due to heart	75%	50%	50%	0	0	0	68.7%
Pure Laceration	Total	1	0	0	0	0	0	1
	Due to heart	1	0	0	0	0	0	1
	Type of Death due to heart	(c)						(1)
	Percent of death due to heart	100%	0	0	0	0	0	100%
Laceration and Contusion	Total	2	1	2	0	0	0	5
	Due to Heart	1	1	2	0	0	0	4
	Type of death due to heart	(c)	(c)	(c,c)				(4)
	Percent of death due to heart	50%	100%	100%	0	0	0	80%
Perforated Chamber	Total	2	1	0	1	5	0	9
	Due to Heart	2	1	0	1	4	0	8
	Type of death due to heart	(c, h)	(t)		(c)	(h,h, h,t)		(8)
	Percent of death due to heart	100%	100%	0	100%	80%	0	88.8%
Embolus to Heart	Total	0	1	0	0	0	0	1
	Due to Heart	0	1	0	0	0	0	1
	Type of Death due to heart		(c)					(1)
	Percent of death due to heart	0	100%	0	0	0	0	100%

This table portrays the incidence of deaths attributable to the heart with reference to the type of lesion and part of heart involved. In addition they are classified as to the type of deaths; viz:-

Statistical Appendix. contd.

(c) death due directly to myocardial lesion. Usually sudden death from infarction or fatal arrhythmia. 11

(h) death due to exsanguination from the heart. . . 4

(t) death due directly to tamponade. 2

(x) heart lesion is an essential contributory causes of death. 3

Figures or letters in parenthesis also refer to deaths due to the heart.

Statistical Appendix. contd.

TABLE XXVI

Incidence of Repair of Heart Lesions

		Ventricle			Auricle		Right auricle and ventricle	
		Left	Right	Both	Left	Right		Total
Lesions seen at autopsy only:	Laceration	1	1	2	0	0	0	4
	Perforation	1	1	0	1	3	0	6
Lesions seen at operation:	Laceration	11	3	0	0	1	1	16
	Perforation	6	2	0	1	4	0	13
TOTAL		19	7	2	2	8	1	39
Cases Visualized at Operation								
Complete repair of:	Laceration	1	2	0	0	0	1	4
	Perforation	6	1	0	1	2	0	10
Partial repair of:	Laceration	2	0	0	0	0	0	2
	Perforation	0	0	0	0	0	0	0
No repair:	Laceration	8	1	0	0	1	0	10
	Perforation	0	1	0	0	0	0	1
Repair attempted but failed	Laceration	0	0	0	0	0	0	0
	Perforation	0	0	0	0	2	0	2

In this table lacerated wounds with and without contusions are grouped together as laceration. All wounds communicating with the heart chambers are grouped together under perforation. Lesions seen at operation are broken down into types of repair performed.

Statistical Appendix. contd.

TABLE XXVII

Foreign Body Removal

	Pericardium	Pericardial Sac	Myocardium	Completely in Chamber
No. of cases	4	3 (2 probable)	10	4
Removed	4	1	3	1
Not Removed		2 (both probable)	7	3
Found at autopsy			5	3

TABLE XXVIII

Total Deaths

Time of Death		Pure Thoracic	Thoraco-Abdominal	Total
Preoperatively	Deaths	1	1	2
	Due to heart	h	c	2
Before surgery completed or immediately postoperative	Deaths	5	5	10
	Due to heart	c,c,h,t	c,c,h,t	8
1 - 5 hours Postoperative	Deaths	1	3	4
	Due to heart	c	c,x	3
6 - 12 hours Postoperative	Deaths	0	2	2
	Due to heart	0	0	0
13 - 24 hours Postoperative	Deaths	5	1	6
	Due to heart	c,h,x	c	4
25 - 48 hours Postoperative	Deaths	0	1	1
	Due to heart	0	x	1
Over 48 hours Postoperative	Deaths	1	1	2
	Due to heart	c	c	2
Total Heart Cases		35	22	57
Deaths	Total	13	14	27
	Due to heart	10	10	20
Mortality	Overall	37.14%	63.63%	47.37%
	Due to heart	28.57%	45.45%	35.09%

Statistical Appendix. contd. (Table XXVIII, contd)

Deaths among patients with cardiac lesions. Segregation into pure thoracic and thoraco-abdominal wound categories with reference to time of occurrence. Deaths due directly to the heart are listed with reference to type of death as well.

See Table XXV for explanation of symbols, c, h,t, and x.

TABLE XXIX

Time of Occurrence of Deaths Due to Heart

Lesion	Pre op.	During Surgery or immed-iately postop.	1-5 Hrs	6-12 Hrs	13-24 Hrs	25-48 Hrs	Over 48 Hrs	Total
Contusion	c	c	x		c,x	x		6
Pure Laceration		c						1
Laceration and Contusion		c	c,c		c			4
Perforated Chamber	h	c,h,h, t,t			h		c	8
Embolus to Heart							c	1
Total	2	8	3	-	4	1	2	20

Lists deaths due to heart with reference to time cardiac lesion, and type of death. See Table XXV for explanation of symbols c,h,t, and x.

Statistical Appendix. contd.

TABLE XXX

Cardiac Fatalities With Reference to Surgical Correction

Heart Lesion	No. Cases	Would have been benefited by surgery	Possibly Benefited	Could not have benefited from surgery
Contusion	6			6
Pure Laceration	1			1
Laceration and Penetrating	4		1 (c)	3
Perforating Chamber	8	7(c,h,h,h,h,t,t,)		1
Embolus to Heart	1	1 (c)		
TOTAL	20	8	1	11

See Table XXV for explanation of symbols c,h,t.

TABLES OF

THORACO-ABDOMINAL WOUNDS

TABLE XXXI

Wound Location

Wound Entrance	Diaphragm Involved	No. Cases
Right chest	Right	405
Right chest	Left	6
Right chest	Bilateral	7
Right abdomen	Right	18
Right abdomen	Left	12
Left chest	Left	403
Left chest	Right	3
Left chest	Bilateral	13
Left abdomen	Left	27
Left abdomen	Right	9

Illustrates the various combinations of wounds as to entrace of missile and diaphragm involved.

TABLE XXXII

Causative Agent

Causitive Agent		No. Cases
Fragment	Artillery	590
	Mine	34
	Bomb	6
	Grenade	4
Total fragment		634
Gun shot wound		245
Not recorded		24

Illustrates type of agent causing the wounds in this series of cases.

TABLE XXXIII

Time Lag

Time Lag in Hours	Fatal Cases	Cases that Survived	Total	Mortality
0 - 6	64	157	221	28.96%
6 - 12	96	304	400	24.00%
12 - 18	39	83	122	31.98%
18 - 24	20	34	54	37.04%
24-- 30	9	14	23	39.13%
30 +	8	26	34	23.53%
Not recorded	11	38	49	22.45%
Total	247	656	903	27.35%

Depicts time interval from time of injury (as recorded on Emergency Medical Tag) to time of operation.

TABLE XXXIV

State of Shock on Admission

	Cases that Survived	Cases that Died	Total	Mortality
Cases	656	247	903	27.35%
No shock	137	8	145	5.52%
Mild	66	10	76	13.16%
Moderate	143	31	174	17.82%
Severe	111	164	275	59.64%
Not recorded	199	34	233	14.59%

Compares the clinical impression, recorded by the surgeon, as to the state of shock in the cases that lived and those that died.

TABLE XXXV

Organs Involved

Organ	Right Diaphragm Cases	Right Diaphragm Deaths	Left Diaphragm Cases	Left Diaphragm Deaths	Bilateral Diaphragm Cases	Bilateral Diaphragm Deaths
Liver	407	96	82	34	18	7
Spleen	2	1	272	77	5	2
Right kidney	34	33	5	2	0	0
Left kidney	0	0	82	36	0	0
Pancreas	6	4	26	11	1	1
Adrenal	1	0	2	0	0	0
Stomach	32	17	167	71	12	5
Duodenum	17	12	2	1	0	0
Jejunum	11	7	62	29	1	0
Ileum	13	4	9	1	0	0
Cecum	3	1	0	0	0	0
Ascending Colon	8	6	2	2	0	0
Hepatic Flexure	18	13	4	2	0	0
Transverse Colon	13	8	62	25	1	0
Splenic Flexure	2	1	54	28	1	1
Descending Colon	0	0	23	8	0	0
Gall Bladder	12	9	0	0	1	1
Common Duct	2	2	0	0	0	0
Portal Vein	1	1	0	0	0	0
Ureter	0	0	1	1	0	0
Vena Cava	4	4	1	1	0	0

Illustrates the incidence of injury to the various organs. See Table XXXVIII for incidence of injury to single organs.

TABLE XXXVI

Mortality With Reference to General and Thoracic Surgical Teams

	G.S.	T.S.	Total
Cases	729	174	903
Deaths	213	34	247
Mortality Percent	29.22%	19.54%	27.35%

Reveals mortality percentage of thoraco-abdominal injuries in the series operated on by the General Surgical Teams (GS), the series operated on by the Thoracic Surgical Teams (TS), and the total for the entire group.

TABLE XXXVII

Mortality With Different Operative Approaches

Method of Approach	No. Cases	Deaths	Mortality
Thoracotomy only	448	91	20.3%
Laparotomy only	202	77	38.1%
Thoracotomy first (no transdiaphragmatic abdominal repair) then Laparotomy	144	37	25.7%
Laparotomy first then Thoracotomy	74	26	35.1%
Thoracotomy first with transdiaphragmatic abdominal repair, then Laparotomy	20	7	35.0%
Combinded incision across the costal margin onto abdomen	6	2	33.3%
Nonoperated	3	1	33.3%
Died before surgery completed	6	6	100.0%
Totals	903	247	27.35%

Illustrates the mortality percentage with refernce to the operative approach.

TABLE XXXVIII

Mortalities with Reference to Combinations of Organs

Organs	No. Cases	Deaths	Mortality
Liver	297	35	11.8%
Spleen	95	10	10.5%
Liver and kidneys	59	14	27.7%
Spleen and stomach	43	18	41.8%
Liver and stomach	36	12	33.3%
Stomach	30	11	36.6%
Peritoneal cavity only	26	3	11.5%
Spleen and kidney	27	4	14.8%
Spleen and left colon	19	4	21.0%
Left colon only	18	6	33.3%
Spleen, kidney and left colon	12	6	50.0%
Liver, spleen and stomach	11	3	27.3%
Spleen, stomach and left colon	8	4	50.0%
Spleen, kidney and stomach	9	3	33.3%
Liver and small intestines	9	1	11.1%
Liver, stomach and colon	8	5	62.5%
Liver, kidney and right colon	5	4	80.0%
Liver, small intestines and left colon	6	5	83.0%
Liver, stomach and biliary tract	6	4	66.6%
Kidney	11	4	36.3%
Stomach and left colon	8	2	25.0%
Spleen and small intestine	9	0	0.0%
Liver and Spleen	7	3	42.8%
Stomach, small intestine and colon	6	2	33.3%
Small intestine and left colon	6	3	50.0%
Liver and right colon	7	4	57.1%
Kidney and stomach	4	1	25.0%
Liver and left colon	3	1	33.3%
Spleen, stomach and pancreas	3	2	66.6%
All other combinations* (56)	115	73	63.5%

Reveals the combinations of organs injured and the mortality for each group.

* Chiefly multiple and severe combinations.

TABLE XXXIX

Mortality with Reference to Side Involved

Diaphragm Involved	No. Cases	Deaths	Mortality
Right	435	103	23.55%
Left	448	136	30.35%
Bilateral	20	8	40.00%

Illustrates mortality percentage with reference to the side of the diaphragmatic injury.

TABLE XL

Mediastinal Injuries

Type Injury	No. Cases	Deaths	Mortality
Ventricular Myocardium and Pericardium	13	8	66.6%
A-V Junction and Pericardium	1	1	100.0%
Pericardium only	13	4	30.8%
Esophagus	1	1	100.0%
Posterior Mediastinum	2	1	50.0%
Totals	30	15	50.0%

TABLE XLI

Technical Procedures

Total Cases	903
Bronchoscopy, preoperative	2
Bronchoscopy, at close of operation	110
Pleural drainage	326

Lists recorded cases of Bronchoscopy and Intercostal, closed, pleural drainage.

TABLE XLII

Causes of Death

Cause	Op Day	1	2	3	4	5	6	7	8	9	10	11	14	15	Tot	%
		Postoperative Day*														
Shock	40	59	18	4	1										122	49.4
Post-traumatic uremia				8	5	4	4		1		1				23	9.3
Peritonitis		6	2	4	1		2	1	1	1		1	1		20	8.1
Pneumonia			2	7		3	1	2	2						17	6.9
Pulmonary embolus		1	2	2	1			1	1		1	1			10	4.0
Atelectasis	3		1	1	2										7	2.8
Empyema								1	1	2			1		5	2.0
Peritonitis and pleuritis		2	2												4	1.6
Hemorrhage	4														4	1.6
Cardiac Tamponade	1	2													3	1.2
Blast		2	1												3	1.2
Overlooked intest. perforation		2													2	0.8
Pressure Pneumothorax					2										2	0.8
Gas gangrene						1		1							2	0.8
Disruption of diaphragm								1						1	2	0.8
Mismatched blood		1													1	0.4
Mediastinitis			1												1	0.4
Fat embolism				1											1	0.4
"Liver" death						1									1	0.4
Morphinism		1													1	0.4
Bronchoscopy	1														1	0.4
Meningitis				1											1	0.4
Liver abscess											1				1	0.4
No record															13	5.3
Totals	49	76	29	28	12	9	7	7	6	3	3	2	2	1	247	100
Percent	19.8	30.1	11.7	11.3	4.9	3.7	2.8	2.8	2.4	1.2	1.2	0.8	0.8	0.4	100	

* No deaths recorded on 12th or 13th postoperative days

TABLE XLIII

Grouped Causes of Death

Cause		No. Cases	Percent of Deaths
Total deaths		247	100%
Shock		122	49.39%
Intra-	(Pneumonia	17	6.85%
Thoracic	(Atelectasis	7	2.83%
Causes	(Pulmonary embolus	10	4.05%
	(Empyema	5	2.02%
	(Miscellaneous	13	5.26%
Total Intrathoracic causes		52	21.05%
Abdominal	(Peritonitis	20	8.09%
	(Liver	2	0.81%
	(Hemorrhage	4	1.62%
	(Overlooked intestinal perforations	2	0.81%
	(Peritonitis and Pleuritis	2	0.81%
Total abdominal causes		30	12.15%
Posttraumatic uremia		23	9.31%
Miscellaneous		7	2.83%
Not recorded		13	5.22%

This table groups the causes of death listed in Table XLII under the main headings as indicated.

THORACIC WOUNDS

Part II

REPARATIVE THORACIC SURGERY IN BASE SECTION HOSPITALS

REPARATIVE THORACIC SURGERY IN BASE SECTION HOSPITALS

One of the most significant advances in military surgery has been the development of a program of early reparative surgery in the base section hospitals of an overseas Theater. This has been based on the concept of the continuity of surgical care from the most forward areas to the Zone of Interior, even though the wounded soldier passed through many installations and was cared for by many medical officers.

The establishment of centers in base section hospitals for the study and treatment of specialized surgical problems has had a far-reaching effect on increasing the number of soldiers returned to active duty in the Theater and on minimizing the crippling sequelae of infection. Nowhere has the value of such a program been more apparent than in the treatment of thoracic casualties. The success of the earliest Thoracic Center established in North Africa has led to their uniform employment in the Mediterranean Theater and to their adoption, with slight modifications, in the European Theater of operation.. The value of a base section Thoracic Center is three-fold. First, the concentration of thoracic casualties under trained personnel provides better facilities for observation and care. Secondly, there is the centralized opportunity for evaluating the efficency of prior treatment. Thirdly, the optimum time for initiating reparative procedures often arrives before the patient can be evacuated safely to the Zone of the Interior. During the past two and one-half years, three thoracic surgeons of the 2nd Auxiliary Surgical Group have had the priviledge of supervising eight major thoracic sergices in base section hospitals. Of these, four of the services have been officially designated as Thoracic Centers. During this period approximately 2200 cases of thoracic wounds and injuries were cared for, of which 1669 had intrathoracic pathology.

The reparative phase of intrathoracic wound management involves the application of principles designed to prevent or minimize infection at its inception, and to assure the rapid restoration of normal function. Every effort is made to accomplish this end within the shortest period of time consistent with sound surgical practice. This phase may be considered to have begun as soon as the initial surgery has been completed, and the patient stabilized to the point where he is safely transportable. In the main this phase is the function of General Hospitals in the base. A large experience has indicated that the great majority of patients with intrathoracic

wounds may be safely transported within one week from the time of injury, regardless of whether or not major initial surgery has been done. This permits the institution of necessary reparative procedures at a time consistent with maximum benefit. Thus, it has been possible to do a greater part of the reparative surgery at a time early enough for recovery from these procedures to occur within the period of convalescence from the original wound. The increased utilization of air evacuation and the advancement of General Hospitals in close support of Army have been measures designed to widen the scope, and increase the effectiveness of reparative surgery. Progress made in this important phase of intrathoracic wound management has been no less significant than that achieved in the initial phase.

The main problems treated in these centers have been: The proper definitive management of hemothorax, including its complications of clotting, organization and infection; a rational surgical therapy for posttramatic emphyema; the establishment of sound indications for early pulmonary decortication; the precise localization of intrathoracic foreign bodies and a critical evaluation as to the advisability of their removal. Problems of importance but less frequently encountered have been: Complications of thoracos-abdominal wounds; osteomyelitis of scapula and ribs, and of chondritis; cardiac wounds and cardiac or pericardial foreign bodies.

THE MANAGEMENT OF WOUNDS OF THE THORACIC WALL

One of the earliest problems encountered in the Thoracic Center in North Africa was the proper handling of wounds of the thoracic wall. It soon became apparent that all these wounds should be closed, if possible, before reparative intrathoracic procedures were undertaken. In a group of 144 closures (originally by total wound excision and primary closure) it was found feasible to shorten greatly the time interval between wounding and closure. This was reduced from an average of 21 days to nine days[1]. The criterion for closure was on the basis of gross appearance. Bacteriological studies were not done. The local application of sulfa drugs did not appear to alter healing.

A theater-wide extension of this program was undertaken on all wounds with the result that secondary closure became an essential part of reparative surgery. With the advent of pencillin and a more efficient initial debridement the closures of most wounds have been accomplished in less than five days from the time of wounding. When closed at this time usually suture approximation was all that was necessary.

Chronic parietal sinuses due to costal or chondral infection have been encountered infrequently. These have been opened widely

and the offending material removed. Under penicillin protection, secondary closure usually has been possible within five to seven days. Osteomyelitis of the scapula has been seen at least 10 times, more frequently during earlier experience when some initial debridements of the scapula were not sufficiently radical. All have responded well to free incision and removal of sequestra.

HEMOTHORAX

Hemothorax was present in approximately 75% of all patients with intrathoracic wounds at the time of their arrival at the base. An additional 11% with a prior hemothorax had a dry pleural cavity when admitted to the base section hospitals. The treatment was a continuation of that commenced in forward hospitals; conscientious daily aspirations, without air replacement, until no more fluid could be obtained. The blood was found to be clotted in approximately 10% of a series of 752 cases[2]., although this did not necessarily prevent further aspiration. Needles up to No. 15 gauge were employed and a "currant jelly-like" material successfully removed on many occasions. Clotted hemothorax, however, complicated the picture. Approximately 40% developed empyema. The possible relationship of low grade intraplural infection to clotting is not known at present. Of those not developing infection (60% of all clotted hemothoraces), approximately 16% had primary indications for decortication; 22% were decorticated during removal of foreign bodies and 62% cleared spontaneously. When compared to our 1943 experience[1] there was a significant and pleasing reduction in the percentage of patients requiring decortication for uninfected clotted hemothorax (about one fourth as many). This we believe was due not so much to narrower indications for the operation in 1944 and 1945, as to better treatment of these cases in the forward areas: Prompt and vigorous thoracentesis; early pulmonary re-expansion; and a great reduction in the number of early thoracotomies performed for the evacuation of a hemothorax (see Section on the Initial Surgery of Intrathoracic Wounds, page 412).

CASE REPORT No. 1 - The Resolution of a Clotted Hemothorax Not Requiring Decortication

An American soldier sustained a perforating gun shot wound of the right thorax on 14 June 1944. The missile lacerated the right lung and a right hemopheumothorax developed. Wounds debrided and a sucking wound (wound of exit) was closed. 800 cc. of blood were withdrawn from the right chest and a "flapper-valve" type of intercostal tube inserted. This drained poorly and was removed forty-eight hours after wounding.

Reparative Thoracic Surgery In Base Section Hospitals (Hemothorax cont'd)

Figure 75. - Roentgenogram showing clotted uninfected hemothorax two weeks after injury.

X-ray revealed moderate hemothorax right. Repeated aspirations yielded only a few cc of serum and clot fragment. Diagnosis made of clotted hemothorax. Due to moderate size and lack of evidence of infection within the clot it was allowed to clear spontaneously. Clearing was almost complete within six weeks of the time of injury. (Figure 76).

Figure 76. - Roentenogram one month later. No surgery and no aspirations. Clearing of chest almost complete.

Patient returned to duty 17 August 1944.

THE PATHOLOGY OF ORGANIZING HEMOTHORAX

The process of clotting will frequently lead to organization although the factors responsible for clotting and organization are not entirely clear. The presence or absence of intrapleural air has no apparent bearing on the clotting mechanism. Transient bacterial contamination is a possible factor, at least in some cases. For proper understanding of organizing hemothorax certain fundamentals in its pathogenesis must be considered. These relate particularly to early decortication as a rational therapeutic measure. There is no "thickening" of either the visceral or parietal pleural layers as it is often described roentgenographically. The current practice of referring to such peripheral obscuration by the term "thickened pleura" is a misnomer and should be discontinued. Within two or three days following injury there is deposited a thin layer of clotted blood and fibrin which is continous over both visceral and parietal pleural surfaces. A closed sac or envelope is thus formed, the "inner" surface of which is toward the hemothorax and the "outer" surface, loosely adherent to the pleura (Figure 77).

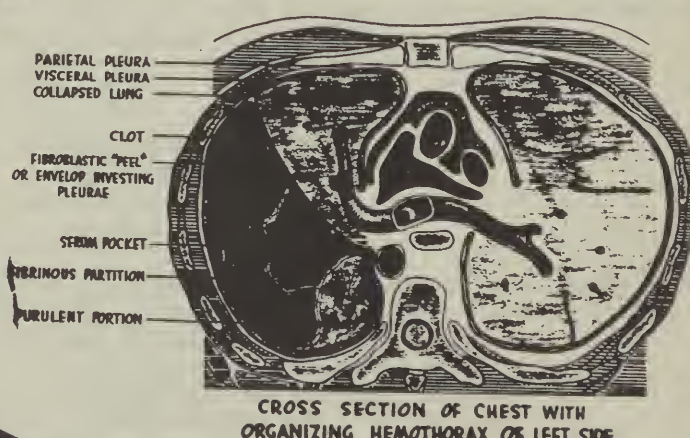

Figure 77. - Cross-sectional diagram showing compression of left lung, loculation of hemothorax, and location of fibroblastic "peel".

Within seven days there is microscopic evidence of fibroblastic and angioblastic proliferation in this layer. The process is first visible extending into the walls of the envelope from the pleural surfaces. The "peel" or "rind" or "fibroblastic membrane" then increases in thickness through the progressive invasion, by fibroblasts,

of the clotted blood and fibrin which become freshly attached to the inner surface of the envelope. Within four weeks, adult fibrous tissue can be seen forming the outer portion of the peel and the fibers and nuclei have arranged themselves roughly parallel to the outer surface. Most of the capillaries, however, extend at right angles to this surface and have obviously penetrated from the pleurae. The advancing inner border of active organization remains composed of young cellular tissue, and even single wandering fibroblasts can be seen. Within six or seven weeks small arterioles with smooth muscle fibers in the walls can be demonstrated at or near the outer surface of the peel. The membrane may reach a thickness of 1 cm. over the visceral pleura. For some reason as yet unexplained, the peel over the parietal pleura is always thicker, more adherent and more vascular, than that on the visceral pleura. When fully developed the peel is an entirely inelastic, fibrous membrane, which, by its firm adherence, keeps the lung compressed and immobilized. Eventually there is complete fibrous tissue, and vascular union with the pleura, which then loses its identity as a limiting membrane.

It has been an important observation that the development of infection and empyema in a hemothorax has not changed the process of organization to any appreciable degree, although there is some evidence that the production of fibrous tissue proceeds at a faster rate, and that there is a firmer union between the peel and the underlying pleura, after infection has supervened. Miscroscopically, the only evidence of inflammation is found on the inner surface of the peel where fibrin or blood clot in the process of organization shows infiltration by varying numbers of polymorphonuclear leucocytes.

THE RATIONALE AND TECHNIQUE OF TOTAL PULMONARY DECORTICATION

The operation of decortication was first proposed in 1893. At that time Fowler[3] pointed out the necessity for removing the fibrous investment on the pleura in chronic suppurative disease if pulmonary expansion was to be obtained. Delorme[4] almost simultaneously and quite independently recognized the same principle. Despite the unquestioned validity of this concept, the procedure never enjoyed wide usage. This was due to several factors. The first of these was the inadequacy of anethesia at that time. Blood transfusions were not available to these early surgeons. The lack of bacteriostatic agents such as the sulfonamides and penincillin made surgery extremely hazardous when it was performed in the face of fresh suppuration. After many months of chronic infection such a degree of cellular intimacy existed between the pleura and the investing layer of organized exudate that attempts at decortication were more often failures than not.

Reparative Thoracic Surgery In Base Section Hospitals (The Rationale and Technique of Total Pulmonary Decortication, cont'd).

The surprisingly large number of patients with organizing hemothorax who have been seen so far in this war, has given us the opportunity to "rediscover" and re-apply the valuable concept of decortication with pulmonary mobilization. The early realization of its possibilities led one of us (Burford) to perform the first decortication in North African theater in May 1943. Detailed studies of the pathogenesis of hemo-organization have been most fruitful in clarifying the therapeutic approach to the problems of organizing hemothorax and its infectious complications.

The indications for decortication have been varied. Its employment in selected cases of infected hemothorax and posttraumatic empyema has been of great value. Decortication with complete visceral pleurolysis has now been performed on more than 120 patients. In approximately 30% the presence of an organizing hemothorax with partial pulmonary compression was a complicating factor in patients whose thoracotomy in the base hospital was primarily for the removal of an intrapulmonary foreign body. In uninfected organizing hemothorax, decortication has an important place in treating a relatively small percentage of patients. The general indications for operation are as follows: Patients in whom there is at least a 50% compression of the lung, especially if the apex is collapsed; in whom aspiration has been unsuccessful and in whom there has been no appreciable pulmonary expansion at the end of four to six weeks following injury. In these individuals decortication will result in immediate pulmonary re-expansion and prevent the development of a possible fibrothorax and chronic pulmonary invalidism. At least, the patient will be saved a prolonged convalescence of many months and the hazards of supervening infection.

An important consideration is the proper selection of the time for operation. From a purely technical point of view, decortation is best performed from 3 to 5 weeks following injury. If performed less than two weeks after injury the peel is thin and friable; the operation is tedious because the poorly defined membrane must be removed piece-meal or meticulously wiped from the pleural surface. When performed too late (probably after 10 to 14 weeks) the fibrous union between peel and pleura is often so firm that a proper cleavage plane cannot be established. The visceral pleura is frequently torn and the lung does not expand readily because of fibrous ingrowths along the septa.

The operation of decortication entails open thoracotomy. Clot evacuation alone is not a sufficient procedure. Concomitant lesions in the thoracic parietes, lung or mediastinum are handled as may be indicated. Important technical considerations are: 1. Meticulous establishment of the proper cleavage plane between peel and visceral pleura; 2. Careful blunt dissection of the peel either digitally or by a guaze "dissector"; 3. Complete freeing of the lung where it is directly adherent to the thoracic wall, to the mediastinum, or along the fissural margins, so that complete circumferential expansion can be obtained. 4. Decortication and mobilization of the

elevated, fixed diaphragm, with particular attention to re-developing the costophrenic sulcus; 5. Deliberate intermittant expansion of the lung under increasing positve pressure, with careful stroking of atelectatic areas; attempts at immediate complete pulmonary re-expansion are ill advised. On removal of the constricting peel there is exposed a grossly normal, thin, translucent, expansible pleura. A considerable amount of oozing occurs, readily explained, when one remembers that numerous capillaries are torn, and left with gaping ends which open on the pleural surface. The bleeding is immediately controlled by expanding the lung with slight postive pressure.

Reference is again made to the greater thickness and vascularity of that portion of the peel which is adherent to the parietal pleura. Removal of this membrane has not resulted in any significant increase in thoracic wall mobility. The bleeding has been relatively severe and, of course, not controlled by pulmonary re-expansion. From our experience, we would condemn the routine removal of this peel as unnecessarily increasing the hazards of the operation, without appreciably adding to the benefits. It is necessary however, to assure a perfectly smooth margin to the entire circumference of reflection. Tags and cuffs of tissue encourage pocketing, and creation of dead space.

The chest wall is inspected and palpated for protrusions and these removed and smoothed up if present. The effort is made throughout the entire procedure to achieve total pulmonary expansion, and the complete obliteration of pleural dead-space. The operation that fails to do this has no chance of succeeding.

It should be emphasized at this point that cross-hatching of the fibrino-fibrous membrane with piece-meal removal is very rarely necessary and has never been advocated in this theater. There not infrequently remain islands of thin, tough membrane, after the removal of what may be called the primary "peel". These must be removed whenever they interfere with complete expansion of the lung.

If a metallic foreign body is present in the lung, or if indriven rib fragments are found to exist removal is carried out at this stage, and the lung sutured with fine silk, nylon, or cotton. Should an intrapulmonary abscess of favorable size be encountered resection should be done and the lung closed. Closure of the esophagus in cases of esophageal lacerations, and excision of a transdiaphragmatic fistula with closure are done whenever present.

Provision for the maintenance of pulmonary expansion is made by the insertion of two, frequently three and occasionally four, intercostal tubes at critical sites. These sites are selected upon a basis of dead-space obliteration and include always the 8th interspace in the posterior-axillary line, and the 2nd interspace in the mid-calvicular line. In infected cases it has been found wise to place a third

tube in the 5th or 6th interspace in the mid-clavicular line. Rarely it has been advisable to place a fourth tube in the 7th interspace in the mid axillary line. All are connected to "water-seal" bottles. Soft rubber tubing with an internal diameter of 10 mm. has proven satisfactory for this purpose with the exception of the upper (2nd interspace) tube. Here a number 12 or 14 pezzar catheter, with the tip cut so that only a flange remains, is employed. These tubes are not to be regarded as foreign bodies so long as they function to promote obliteration of dead space and pulmonary expansion. The moment that they cease functioning they must be removed. Usually it is possible to remove the anterior tubes within 48 hours. The posterior tube may continue to drain serum for four to seven days. In cases which have had a previous rib-resection it frequently happens that the site of preliminary drainage will correspond with the site of election for the posterior tube. Anticipating this, it has seemed advisable when possible to remove the thoracostomy tube three or four days prior to the contemplated decortication in order that shrinkage of the track will occur. At the time of decortication this site is utilized, the edges freshened and closed tightly about the tube.

At the completion of the operation the intercostal nerves are blocked with one percent procaine. The nerve of the interspace of approach, as well as two above, and two below are all that require injection.

The pleural cavity is copiously lavaged with sterile physiological saline solution and aspirated completely dry. All clots and loose tissue are removed and the lung brought to full expansion and tested again for air-leaks. The chest wall is then closed, using sutures of interrupted silk throughout. Pericostal sutures are not used. After completion of the closure 25,000 - 50,000 units of penincillin in 100 to 200 cc. of physiological saline are instilled into the pleural cavity through the tubes, allocating roughly equal amounts to each tube. All tubes are clamped, and the dressing applied. Immediately on arrival in the ward the tubes are connected to "water-seal" bottles, but only the anterior ones are unclamped. The posterior tube or tubes are left clamped for 4 - 6 hours to permit local penincillin effect.

Before leaving the table attention is given to the air-way. In the event moisture is audible after painstaking tracheal catheter aspirations, or if pulmonary re-expansion was difficult or delayed, bronchoscopy is done. Blood is given during operation, the amount required depending upon the magnitude of the procedure. The amount necessary has varied from 1500 to 4000 cc.

THE INFECTIOUS COMPLICATIONS OF HEMOTHORAX

As described above the more serious implications of clotted

hemothorax are mirrored in the 40% empyema rate as contrasted with an 11% empyema rate in cases of liquid hemothorax [5].

Proof of the infection in a hemothorax was based on the finding of organisms in the grossly sanguinous fluid aspirated from patients who showed clinical signs of toxicity. Frequently, however, smears and cultures did not become positive for many days. In these cases infection was presumed if the patient remained toxic, continued to run fever or showed any increase in the amount of pleural fluid which could not be explained on the basis of further bleeding. A wide variety of organisms have been implicated but the frequency which anaerobic streptococci and staphylococci were encountered has been somewhat surprising. Non gas-forming colorstridial organisms have caused infections in a significant number of patients. They have not behaved differently from other bacteria. Clotting and organization have been present in nearly all cases where infection has supervened.

The proper handling of these patients has presented many difficulties. It has always been possible to treat them conservatively aspirate until "thick" pus was present, then drain the empyema. This has been the usual procedure in patients with small infected hemothoraces. When there is a large infected hemothorax, however, with more than a 25% compression of the lung, such a policy will frequently result in extensive, relatively stationary empyema cavities. A large percentage join that deplorable group of patients with chronic empyema who, after months and even years of suppuration, are relieved by exodus or are "cured" by multi-staged, deforming, obliterative operations. In a number of patients with infected hemothorax where the lung was significantly collapsed, we have employed formal thoracotomy with evacuation of all exudate, complete decortication of the visceral pleural peel, immediate pulmonary re-expansion and layered closure of the incision. Follwoing discovery of the intrapleural infection, these operations were undertaken as soon as it was possible to render the patient a satisfactory operative risk. In the great majority of patients so treated, no subsequent empyema developed and there was primary union of the thoracic incision. In the remainder a small, residual, basal empyema was found easy to control. In the early cases, crystaline sulfamilamide was placed in the pleural cavity. More recently, greater protection against residual infection has been gained by the use of local and systemic penicillin.

POSTTRAUMATIC EMPYEMA

Despite the advances in the prewar years in the use of chemotherapeutic agents, particularly the sulfonamides, in the prevention and control of the ordinary pyogenic infections, and despite their application, empyema following intrathoracic wounds still occurred in a high

percentage (22.6 percent) of the cases, in the first Thoracic Center experience. Among the efforts made to decrease this incidence, advances were made in pre-operative therapy and in initial surgical therapy, in that definite indications were established for the performance of initial thoracotomy, and of debridement of the thoracic wall alone. Also the effectiveness of initial surgical therapy was enhanced by the increasing operative skill of the forward surgeons. The advent of penicillin represented an improvement over the sulfonamides in the attempt to minimize the effects of any residual contamination. A rational plan for the management of metallic foreign bodies was involved. And of all the factors involved, that of the persistence of dead space was not the least in importance. Its early obliteration was obtained in a steadily increasing number of cases, as the prompt treatment of hemothorax, and of pneumothorax with or without a bronchopleural fistula, was pursued with increasing vigor.

As a result, during the war it is gratifying to observe that the incidence of empyema fell progressively from its initial 22.6 percent to one of 7 percent in the final phase of the War in the Spring of 1945 [2]. As pointed out previously, this most significant reduction in the incidence of empyema was not the result of advance in any single phase of treatment, but rather the combination of all. A total of 213 empyemas has been drained by thoracic surgeons of this Group.

The mechanism of development of post traumatic empyemas varies considerably. They are caused by a rather wide variety or organisms, both aerobic and anaerobic. The infection may be introduced through the thoracic wall, as a contamination from the abdomen when the diaphragm has been perforated, or from the lung through a bronchopleural fistula. Nearly all post traumatic empyemas develop in a pre-existing hemothorax. Because of its characteristic behavior, this type of empyema has been designated as "hemothoracic empyema". There is no sharp differentiation between infected hemothorax and hemothoracic empyema. The infection has been classified as an empyema as soon as gross pus or purulent exudate was evident in aspirated material. The source of the contamination and the type of organism may vary but neither are important considerations. In effect, hemothoracic empyema develops in a closed hemotoma of the intrapleural space, since the limiting walls of the infected cavity are not the pleural surfaces themselves but are composed of a thickened membrane or peel of organizing fibrin which covers and protects the pleurae. This factor probably accounts for many of the differences from post pneumonic empyema that such an infection exhibits. In a developing hemothoracic empyema, purulent exudate may not bee seen for many days; "thick" pus may not form for several weeks. There is a greater tendency for the empyema to pocket, thus increasing the necessity for multiple drainage procedures. Total empyemas are most frequent and in these, pulmonary re-expansion is indefinitely prolonged. Even in patients with extensive hemothoracic empyemas of many weeks' duration, no periosteal reaction of the ribs has been seen and the ribs have not become triangular.

In the treatment of established hemothoracic empyema, the principle of adequate dependent drainage with rib resection has been mandatory. There is no place for intercostal drainage except in the rare instance when a patient may be too ill for rib resection. In all instances there is a tremendous amount of partially degenerated clot, fibrin and exudate which will promptly clog an intercostal catheter. The general practice of waiting for thick pus to develop must be modified if the patient is to be saved from days or weeks of toxic absorption. There seems to be no urgent reason for using a water-seal bottle to make the drainage air-tight unless the empyema has developed with unusual rapidity. In hemothoracic empyema, mediastinal immobility depends on the amount of organization which has occurred in the pre-existing hemothorax and is, therefore, roughly proportional to the length of time since injury. There is no relationship between mediastinal fixation and either the duration of the infection or the thickness of the purulent exudate.

As stated above, total pulmonary decortication was early recognized as a vital operation in treating total subacute or impending chronic empyemas. Until March 1944, these were all secondary decortications, that is, performed following some type of drainage operation. In March under penicillin protection, the first primary decortication (without preliminary drainage) was performed (Samson) and since that time primary decortications have been performed in an increasing number of cases. The principles have been described in detail elsewhere [6]. To date members of this organization have performed approximately 64 decortications for empyema, with no deaths due directly to the operation. In approximately 75% of the cases, the lung has re-expanded without the formation of a residual empyema. In most of the cases in which residual empyema occurred there had been persisting pulmonary pathology necessitating correction at the time of decortication. This included obliteration of bronchial fistulae, wedge resections because of multiple fistulae, and resections or curettage for posttraumatic abscesses.

Of further interest is the comparison between results of primary and secondary decortations. In the latter, the percentage of residual empyema has been greater than in the former. At least three factors were responsible. First, the patients requiring preliminary drainage were sicker as a group. Secondly, when intrathoracic wounds presumably were more severe and the ensuing infection more toxic. Thirdly, the interval between wounding and operation was greater in secondary decortications due both to the original poor condition of the patients and to the added time necessary for recovery from the preliminary drainage operation.

<u>CASE REPORT</u> <u>Posttraumatic Empyema Cured By Early Pulmonary Decortication Without Preliminary Drainage.</u>

An American soldier was wounded in action 4 June 1944. Suffered

severe penetrating shell fragment wound of the right thorax with laceration of the right lung, right hemopneumothorax, and retained intrapulmonary foreign body. Thoracotomy was performed on the day of injury at a forward evacuation hospital and the foreign body removed from the lung and the laceration of the lung sutured. Following an immediate uneventful postoperative period the patient developed a clotted hemothorax of the right chest and began running a daily temperature elevation of 101° - 102° F. In the base hospital pus was eventually recovered from the hemothorax from which staphylococcus aureus grew (Figure 78 .)

Figure 78. - Roentgenogram showing right sided pneumopyothorax and a 50 percent compression of the lung.

Thoracotomy with decortication was done approximately four weeks after injury without premilinary drainage, and a primary cure obtained (Figure 79)

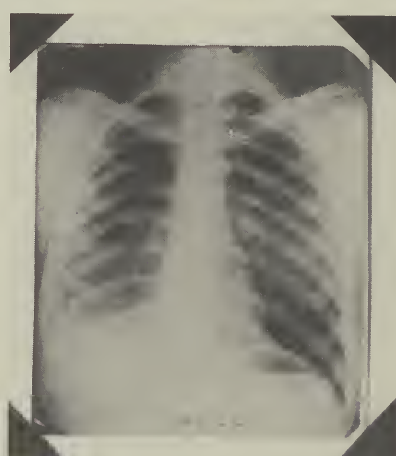

Figure 79 . - Roentgenogram two weeks after total pulmonary decortication. Complete pulmonary re-expansion and primary cure.

CASE REPORT. Cure Of Impending Chronic Empyema By Decortication.

An American soldier was wounded in action 31 May 1944 when struck in the right chest by a shell fragment. Sustained a sucking wound laceration of the right lung and a hemopneumothorax of the right pleural cavity. "Forward" thoracotomy performed with removal of shell fragment from lung, suture of lung and evacuation of blood from right pleural cavity. When admitted to the center eleven days later a massive empyema had developed. Patient was judged to be too ill to do a decortication upon without preliminary drainage. Hence a re-opening of the thoracotomy incision was done and the empyema adequately drained through the bed of the rib that had been resected at the time of the initial thoracotomy. The infection was adequately drained, the lung did not satisfactorily re-expand and the cavity reached a static state (Figure 80).

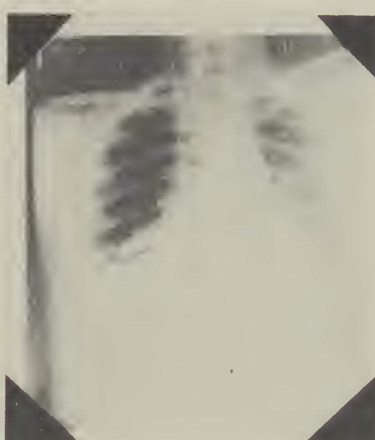

Figure 80. - Four weeks after adequate rib resection drainage and $5\frac{1}{2}$ weeks after wounding. No tendency for lung to re-expand. Impending chronic empyema.

An impending chronic empyema was recognized as threatening and a decortication was done six weeks after adequate drainage had been established. The lung was freed of its fibrino-fibrious membrane without difficulty and promptly re-expanded at the time of operation. Complete primary cure obtained (Figure 81).

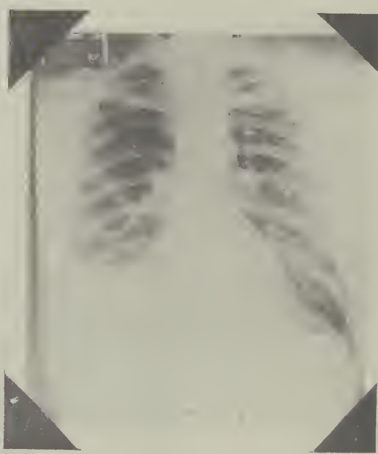

Figure 81 . - Roentgen film two weeks after total pulmonary decortication. Lung completely re-expanded. No residual empyema.

INTRATHORACIC FOREIGN BODIES

As indicated elsewhere [7] experience has increasingly tended to establish the base hospital as the site for the removal of retained metallic intrathoracic foreign bodies when removal seems indicated. Information accruing in thoracic centers has supported this principle.

The establishment of a sound policy in regard to intrathoracic foreign bodies depended initially upon proceeding according to principles evolved without satisfactory precedent until experience could either justify or intelligently modify that policy [8].

Review of cases of intrathoracic wounds when seen in the base, revealed that approximately 25 percent had metallic foreign bodies retained in either the lung or pleura. Of these, approximately four percent were in the pleural cavity. The problem of the retained foreign body is one of major importance.

With the establishment of the first Thoracic Center in the Theater a policy was decided upon of removing all retained intrathoracic metallic foreign bodies of 0.8 cm. or above, as measured on roentgen films. This size was considered to be consistent with ease of palpation at operation. Later a re-evaluation of experience occasioned an elevation of the size limit so that the policy was changed to recommend the removal only of those of 1.5 cm. or above in one diameter. This latter figure has proven increasingly sound and added experience demonstrated no reason to alter the size limit of 1.5 cm.

Since the great majority of cases were under observation from one week to two months after wounding, and many as long as 90 days, an opportunity was offered to determine what happens to retained intrathoracic missiles during the first 60-90 days. In a consecutive series of 291 retained intrathoracic foreign bodies (exclusive of heart and pericerdium), it was found that a significant number of these patients developed complications [9] Figure 82. In the intrapulmonary and mediastinal group there was an empyema rate of 12 percent and abscess, hemoptysis and recurrent fistulae associated with the foreign bodies accounted for an additional 11 percent of complications. The empyema rate in retained intrapleural foreign bodies was 38 percent. All complications believed due to retained intrathoracic foreign bodies occurred in 25 percent of the group; or in 15 percent if empyema associated with intrapulmonary foreign body was excluded.

Reparative Thoracic Surgery In Base Section Hospitals, cont'd.

COMPLICATIONS OF INTRATHORACIC FOREIGN BODY

TOTAL NUMBER OF INTRATHORACIC F.B.	291
NUMBER OF INTRAPULMONARY AND MEDIASTINAL F.B. (EXCLUSIVE OF HEART AND PERICARDIUM)	252
LUNG ABSCESS	4
DELAYED OR RECURRENT HEMOPTYSIS	4
SECONDARY INTRAPLEURAL HEMORRHAGE FROM LUNG	2
LATE OR RECURRENT BRONCHOPLEURAL FISTULAE	18
MEDIASTINAL ABSCESS WITH MEDIASTINAL F. B.	2
EMPYEMA WITH INTRAPULMONARY F. B.	30
TOTAL COMPLICATIONS ASSOCIATED WITH INTRAPULMONARY AND MEDIASTINAL F. B.	60-23%
NUMBER OF INTRAPLEURAL F. B.	39
EMPYEMA WITH INTRAPLEURAL F. B.	15-38%
TOTAL COMPLICATIONS OF INTRAPULMONARY, MEDIASTINAL AND INTRAPLEURAL F. B.	75-25%
IF EMPYEMA OF INTRAPULMONARY F. B. GROUP IS EXCLUDED	45-15%

Figure 82 . - See Text.

In view of the considerable discussion that has occurred pertaining to the relative incidence of empyema in intrapleural and intrapulmonary metallic foreign bodies, these figures are enlightening. In the intrapleural group empyema occurred in 38 percent, while in the intrapulmonary group the incidence of empyema was 12 percent [2]. This latter figure is strikingly close to the over-all incidence for empyema in the same period. (Figure 83).

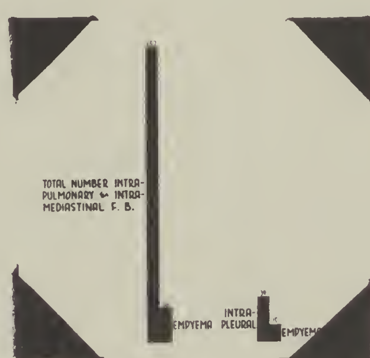

Figure 83 . Numerical incidence of empyema in cases of intrapulmonary and intrapleural foreign bodies (291 cases).

This corroborates the generally held opinion that intrapleural foreign bodies are more likely to cause trouble than intrapulmonary missiles. It should be pointed out that the incidence of intrapleural foreign bodies is not high enough (3.7 percent) even with their higher complication incidence (38 percent) to significantly "weight" the series as a whole.

The majority (74 percent) of these complications developed during the second and third weeks following injury. The earliest complication exclusive of the empyema group, was a lung abscess which was proved to be present at one week after injury. Only four complications developed prior to ten days, and none of these was in the intrapleural group.

These figures are of the utmost importance since they give valid factual correction to the many prevalent misconceptions concerning the innocuousness of retained intrathoracic missiles. Though representing only one series, the occurrence of 15 percent significant complications during the first 90 days must be accepted as evidence that the retained missile is, on the contrary, a very significant

source of danger to the thoracic casualty and must be considered as such in the modern reparative management of these injuries. That so few complications developed before ten days justifies the policy of awaiting arrival in the base before removal is carried out.

No correlation was apparent in this study between size, configuration or locations of missiles and a predilication for engendering complications, except in one regard. Missiles located in the periphery of the lung gave rise to a higher incidence of difficulty than did those located in the hilum. This is strikingly at variance with the view popularly held that the missile lying in close proximity to vasular or bronchial structures in the hilum is the one more likely to occasion trouble. On the other hand, foreign bodies near the hilum which do give rise to complications are much more difficult to remove.

Ideally, thoracotomy for the removal of intrathoracic foreign bodies should be performed between the 5th and 14th days following injury. In most instances this gives adequate time for the secondary closure of wounds of the thoracic wall and for adequate pulmonary recuperation, both factors of the utmost importance in lowering the risk of operation. The elimination of granulating wounds from the thoracic wall prior to thorcotomy greatly reduces the hazard of infection. Pulmonary recuperation (recovery from the "traumatic wet lung" syndrome) entails re-aeration of alveoli, absorption of interstitial fluid, re-establishment of complete tracheobronchial patency, and at least partial disposal of any extravasted intrapulmonary blood. The influence of these factors on mortality should be obvious. Technically, it is far easier to palpate metallic fragments in crepitant aerated pulmonary tissue than in a boggy indurated parenchyma. Furthermore, the lung is better able to sustain lobotomy if there has been some recovery from the initial injury.

After three to four weeks, thoracotomy is somewhat more difficult. With the increased fibrosis present around intrapulmonary foreign bodies at that time repair and closure of the parenchymal incision is more uncertain. Extensive intrapleural adhesions of relatively firm fibrous tissue may increase the difficulty of palpating adequately the lung and separation of these adhesions is not always easy. The greater incidence of complications after the second week will increase the hazard of operation.

In general, a posterior intercostal thoracotomy is employed, usually without resecting or sectioning ribs. The lung is freed and decorticated if necessary so that bi-digital palpation can be effected. With the lung collapsed, sharp incision is made over the foreign body where it is nearest the surface. The wound is closed with fine interrupted black silk in two layers, the pleural cavity thoroughly lavaged, the lung expanded and thorax usually drained with two water-seal tubes.

When the foreign body is in the hilar region, it is exposed by careful blunt dissection. Associated abscesses are either curretted out, or a wedge resection performed if the lesion is peripheral. There is no hesitation in removing intrapulmonary foreign bodies at the time of decortation for massive empyema.

In a consecutive series of 102 thoracotomies for foreign bodies [9] there were no deaths and no permanent disability. Significant complications occurred 10 times, or nine percent. (Figure 84).

COMPLICATIONS OF THORACOTOMY FOR FOREIGN BODY

WOUND INFECTIONS	3
SUBJACENT EXTENSION TO PLEURAL CAVITY WITH SMALL EMPYEMA	3
EMPYEMA (BASAL) UNASSOCIATED WITH WOUND INFECTION	1
TOTAL POST-OPERATIVE EMPYEMAS	4
CLOTTED HEMOTHORAX	1
THROMBOPHLEBITIS	1
POST-OPERATIVE ATELECTASIS	1
SECONDARY HEMORRHAGE	1
BRONCHOPLEURAL FISTULAE	2
TOTAL NUMBER OF COMPLICATIONS	10
PERCENT	9.+%
PERMANENT DISABILITY	0
MORTALITY	0

Figure 84. - Number of complications arising in 102 Thoracotomies for the removal of the Intrathoracic Foreign Bodies.

The graphic comparison with complications arising as the result of retained foreign bodies is shown. (Figure 85).

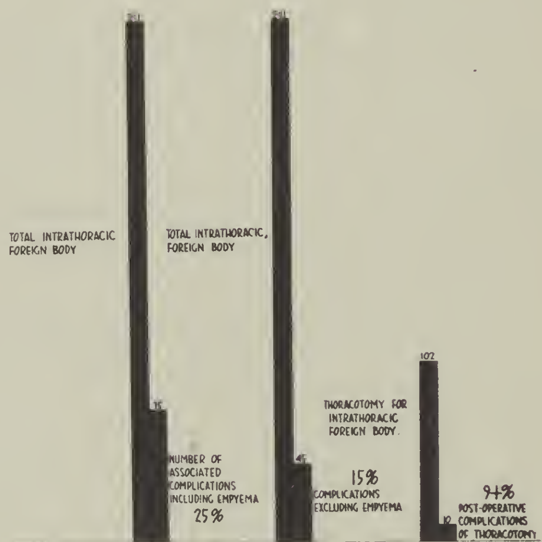

Figure 85. - Comparison of complication rates with and without thoracotomy in retained foreign bodies.

Foreign bodies of 1.5 cm. or more were removed routinely from the mediastinum. Indications for the removal of foreign bodies from the heart and pericardium were conservative. In general these were not disturbed unless the patients had symptoms of cardiac or percardial dysfunction.

Precise pre-operative localization of intrathoracic foreign bodies is of course essential to their successful removal. Principles important in accurate localization have been stressed by Burbank et al [10]. These include roentgen films in two or more planes, fluoroscopy, "spot" films under fluoroscopic guidance and the utilization of air in either the pleural or peritoneal cavities or both. Complicated methods such as the parallax and the use of electric locators have had no place in localization. The most troublesome problems have arisen when the foreign body was either in the region of the diaphragm or in the periphery of the chest. Pneumoperitoneum has been helpful in localizing the former group, while a small artificial pneumothorax has occasionally been necessary to determine whether a peripherally located missile was just within the parietal pleura or whether it lay entirely extrapleurally.

CASE REPORT. Intrapulmonary Metallic Foreign Body With Removal By Thoracotomy.

An American nurse sustained a penetrating wound of the right thorax on 29 March 1944 when struck by a bomb fragment. Patient sustained a sucking wound of the right chest and a right sided hemopneumothorax. The bomb fragment lodged in the right upper lobe. The wound of entry was debrided and the sucking wound closed. Thoracentesis was done. Secondary closure of debrided wound done five days after wounding.

Roentgen and fluoroscopic localization revealed fragment of 1.5 cm. greatest diameter to be lying in upper lobe of right lung. (Figure 86).

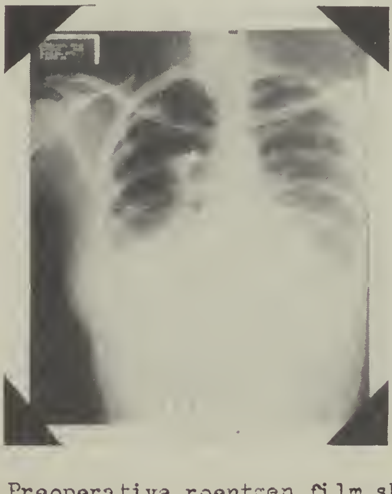

Figure 86 . Preoperative roentgen film showing metallic foreign bodies in right upper lobe.

Thoracotomy without costal section or resection was done four weeks after injury and the fragment removed. The patient made an uneventful recovery and was discharged to the Zone of the Interior for re-assignment. (Figure 87).

Figure 87. Roentgenogram two weeks after removal of shell fragment. Immediate, complete pulmonary re-expansion.

PULMONARY CONTUSION, HEMOTOMA AND BLAST INJURY

Practically every intrathoracic wound results in some degree of injury to the lung. This is made manifest clinically by hemoptysis, and roentgenographically by areas of obseuration of greater or less extent. In the vast majority, the lesions are regressing by the time the patient arrives at a base section hospital and no treatment is necessary except to insure adequate tracheobronchial drainage. In contusión,, there is extravastion of blood into the interstitial tissue and alveoli with rupture of some of the walls of the latter. A true hemotoma or "blood tumor" is caused by complete breakdown of a portion of lung and a localized collection of blood. Roentgenographically the shadows are round or oval and often there are fluid levels indicating a bronchial connection. At times, contusions and true hemotomas cannot be differentiated clinically. Often the patient continues to expectorate blood for many days. Nearly all of these regress rapidly without specific treatment.

CASE REPORT. Regression Of Hematoma (Or Contusion) Of Lung.

An American soldier was wounded in action 24 May 1944 when a large shell fragment penetrated the left chest. Sustained laceration of left lung and a left hemopneumothorax. Wound debrided, sucking wound closed and shell fragment removed from left chest wall. Repeated thoracentesis.

Roentgenograms showed large intrapulmonary hemotoma of left lung (Figure 88).

Figure 88 . Roentgenogram six days after wounding showing large hemotoma of left lung.

This regressed favorably and had almost entirely disappeared within six weeks of injury (Figure 89).

Figure 89 . Film taken six weeks later, process almost entirely cleared except for residurun at periphery in upper pulmonary field.

Note: A proper understanding of intrapulmonary hemotomas is highly important to those charged with the management of thoracic wounds.

Their behavior is almost universally benign and infection practically never supervenes in them if a foreign body is not present. They clear rapidly, usually within four to six weeks after injury.

They frequently show central excavation by x-ray and have been mistaken for abscesses of the lung, particularly when the patient happened to present a concomitant fever. No permanent damage to the lung has been observed, even in the massive hemotomas. In rare instances hemotomas may become complicated by infections or may rupture into the pleural cavity. Surgery then may be undertaken as indicated.

Pure blast injury of the lungs has never caused any complications in patients who have lived long enough to be admitted to a base section hospital.

BRONCHIAL FISTULA

Persistent or recurring bronchial fistulae were noted in approximately six percent of all intrathoracic wounds. Occasionally these were associated with intrapleural or intrapulmonary infection. Under these circumstances the fistula usually was treated concomitantly with the infection, by closure or resection. In some, a localized empyema was drained and the fistula allowed to close spontaneously. In the vast majority there was no associated infection. The treatment in these cases was conservative and aimed at rapid re-expansion of the lung. Ordinarily this was obtained by the insertion of a small water-seal catheter in an upper anterior intercostal space. Occasionally repeated aspirations sufficed to re-expand the lung, although the fistulae often recurred several times.

THORACO-ABDOMINAL WOUNDS

In these cases most of the complications at the base which directly affected the chest were associated with liver wounds. Repairs of the diaphragm, particularly on the left, remained solid and no case of diaphragmatic hernia or eventration was seen. Approximately 25% of a series of liver wounds developed subphrenic abscess, bile empyema or hepatic abscess [2]. The main faults of forward therapy were: Lack of drainage of exposed liver wounds; failure to make the drainage incisions large enough and to place them far enough laterally; and too early removal of drains. Review of the records showed that there was a significant reduction in these complications toward the end of the war. This was due entirely to an increased understanding of the problems involved and to the expert care rendered by surgeons in the forward areas (See Section on Wounds of the Liver, Page 307).

SUMMARY AND CONCLUSIONS

1. A survey has been made of 1,669 patients with intrathoracic wounds whose reparative treatment has been carried out by thoracic surgeons of the Second Auxiliary Group. This work has been done over a period of two and one-half years on eight separate Thoracic Surgical Services, located in North Africa, Italy and France.

2. Charged with the direction of the first Thoracic Center to be established in an overseas theater in this war, thoracic surgeons of this Group were instrumental in establishing the indications for, and elaborating the operative techniques of, many procedures which have become standard in traumatic thoracic surgery.

3. Chief among these have been:

a. Insistance on immediate repeated thoracentesis, maintenance of an adequate tracheobronchial air-way and rapid re-expansion of the lung as the sine qua non of early intrathoracic therapy.

b. The rational treatment of organizing hemothorax, infected hemothorax and hemothoracic empyema based on pathological studies of intrapleural hemo-organization.

c. The re-establishment of the operation of pulmonary decortication together with several important technical modifications, and the application of this operation in the early treatment of selected cases of massive organizing hemothorax, infected hemothorax and extensive hemothoracic empyema.

d. Recognition of the essential points of distinction between postpneumonic and posttraumatic (including hemothoracic) empyema.

e. The development of indications, and of localization and surgical techniques, for the removal of intrathorcic foreign bodies.

4. Brief discussion of the topics listed above has been made.

5. The mortality for patients in base section centers, whose main wounds have been thoracic, has been less than two percent.

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THORACO-ABDOMINAL WOUNDS

THE THORACO-ABDOMINAL CASUALTY

The scope of this report is a discussion of the thoraco-abdominal casualty in the forward hospital, with a presentation of the available data from 903 case records of the 2nd Auxiliary Surgical Group during 1943, 1944 and 1945. No attempt has been made to interpolate for the lack of complete records. Where there are a number of instances in which there are no records, it is so stated.

The thoraco-abdominal wound is defined in this report as a wound produced by a missile perforating the diaphragm with entrance into the pleural and peritoneal cavities. Casualties in which the pleural cavity and peritoneum have been entered by separate missiles without injury to the diaphragm have been excluded. However, a wound of the so-called "bare area" of the liver, incurred by a fragment entering through the chest and diaphragm has been considered a true thoraco-abdominal wound.

A comparison of the incidence of the thoraco-abdominal wound with respect to all abdominal wounds is of interest. During the period covered by this report, 3532 operations on abdominal wounds of all types were performed. The thoraco-abdominal wound comprised 25.5% of this group of abdominal cases.

The great majority of casualties presented are infantrymen of the U.S. Army and of the Wehrmacht, with a scattered number of Allied British and French soldiers, and a few civilians. The age factor, then, is of little significance, because of necessity these men were in the young healthy adult male group.

TABLE I

Age Distribution of Casualties

Up to 20	21 - 25	26 - 30	31 - 40	Over 40	No Record
190	297	176	95	4	141

Artillery and mortar fire was responsible for 590 of the thoraco-abdominal wounds and rifle, machine gun, and pistol fire accounted for 245. The few remaining wounds were caused by bomb, mine, and grenade fragments.

The pattern of entry of the fragments or bullets in thoraco-abdominal wounds shows that 837 of the missiles entered the abdomen through the thorax, against 66 which penetrated the chest through the abdomen. The entrance wound in the chest was equally distributed on the right and the left sides. Four hundred and eighteen missiles entered through the right, and 419 through the left chest. In the 20 cases which had

side-to-side perforations of both diaphragms, the wound of entry was on the right seven times and on the left 13 times. The thoraco-abdominal wound then, is caused by missiles entering through the chest in the greatest proportion of cases, and their distribution is equal as to the right and left.

For the sake of maintaining continuity in presentation of data, and in discussion of points of practice, the report is divided into the preoperative, the operative and the postoperative phases.

THE PREOPERATIVE PERIOD

The preoperative phase of the course and treatment of the casualty with a thoraco-abdominal wound embraces the time period from wounding to operation. It is the period of so-called "time lag". This interval is concerned with the evacuation of the casualty from the battlefield to the hospital, the treatment of shock, and the examination and diagnosis.

Time lag for all patients, and for patients who died, is presented as the number of cases in each six hour interval up to 30 hours, and for those that came to operation at any time after 30 hours. The percentage mortality shows a progressive increase after the first 12 hours, and drops again for those operated on after 30 hours. The greater mortality in the period up to six hours is a reflection of the fact that the nearer to the front the Field Hospital is set up, the higher the expected mortality, because with a short evacuation distance from the line, more of the desperately wounded patients will arrive in the hospital before dying. For example, all the patients in this series with wounds of the vena cava and portal vein are found in this period. The eight casualties that came to operation after 30 hours sustained wounds involving the liver in two cases, the spleen in three instances, the kidney once, and two cases had penetration of the peritoneal cavity without damage to a viscus.

The Thoraco-abdominal Casualty (The Preoperative Period, cont'd).

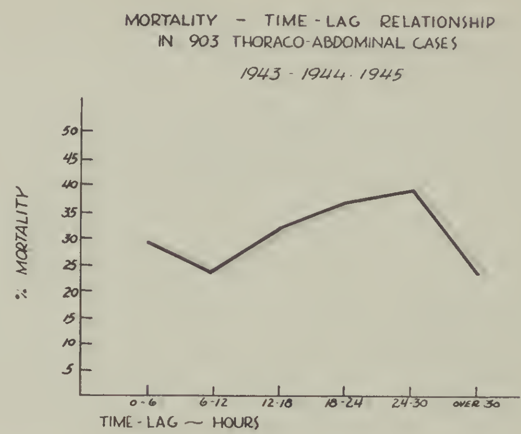

Figure 90 - Mortality - Time Lag. Relationship in 903 Thoraco-Abdominal cases.

TABLE II

TIME LAG - From Wounding to Operation in 903 Thoraco-abdominal Cases and in 247 Fatal Cases

		Time Lag -	All Cases			
0 - 6	6 - 12	12 - 18	18 - 24	24 - 30	Over 30	No Recor
221	400	122	54	23	34	49
		Time Lag -	Fatal Cases			
64	96	39	20	9	8	11
28.9%	24.0%	31.9%	37%	39.1%	23.5%	

The Thoraco-abdominal Casualty (The Preoperative Period, cont'd).

When these casualties were received in the first priority surgical hospital from the division clearing station, measures to combat shock and maintain respiratory equilibrium had already been instituted in the form of occlusive dressings to sucking wounds of the chest, injection of morphine, and infusion of plasma. On arrival at the hospital, 455 casualties with thoraco-abdominal wounds had received an average of 525 cc. of plasma each. One hundred and forty-four patients had not received plasma before admission and the information was missing on this point in 324 instances.

When first seen at the hospital on admission, the degree of clinical shock was recorded by the surgeon as "none", "mild", "moderate", or "severe", or its equivalent. With an increase in the severity of clinical shock on admission, there was a corresponding rise in the percentage of fatalities. There was a 5.5% mortality in these casualties reaching the hospital without clinical evidence of shock, whereas 59.6% of all cases that arrived in severe clinical shock, died subsequently.

TABLE III

Degree of Shock in All Thoraco-Abdominal Patients and in Fatal Cases

None	Mild	Moderate	Severe	No Record
SHOCK IN ALL CASES				
145	75	174	275	233
SHOCK IN FATAL CASES				
8	10	31	164	34
5.5%	13.0%	17.5%	59.6%	

In the shock tent of the hospital, replacement therapy was continued as indicated by the degree of shock and estimated blood loss. The usual practice in those cases requiring replacement treatment was to start an infusion of plasma immediately while waiting for blood to be cross-matched. Thereafter, therapy was continued with blood transfusion. Four hundred and eight patients received an average of 500 cc. of plasma. Two hundred and fifty two casualties did not receive plasma and in 353 instances there were no records of it. Similarly, 619 patients received an average of 1100 cc. of blood in the shock tent, while 60 casualties did not get any. Records were lacking on transfusion in 224 instances.

Further pertinent data relevant to the preoperative treatment of

these patients is not forthcoming from the records, but a discussion of the problem in thoraco-abdominal casualties is important. The intelligent regime of resuscitation and treatment depends on the early recognition of the wound as thoraco-abdominal in extent. Hence, one prompt and thorough examination to discover the site of all wounds, and their position relative to the diaphragm, is paramount. For practical purposes, any perforating fragment which crosses the horizontal zone bounded by the plane of the costal margin and 12th rib below, and the line between the nipple and the angle of the scapula, above, may perforate the diaphragm. Where a penetrating wound was present X-ray examination was a necessity. Antero-posterior and lateral positions preferable in the sitting position for the chest, and with an over-exposure of the film for both abdomen and chest, were important to check the position of the retained fragment or bullet with the site of entry. By this means an effort was made to determine whether or not the zone of the diaphragm had been perforated. Elsewhere the X-ray was of practical use only in confirming the presence of mediastinal shift associated with a hemothorax or a pneumothorax, and of fractured ribs.

Further clinical examination of the casualty was directed at an evaluation of the cardio-respiratory status - the presence of cyanosis, respiratory restriction due to pain, embarrassing hemothorax or pneumothorax, and excessive tracheo-bronchial accumulation of blood and mucus. When present, these were treated in the preoperative period by oxygen through a nasal catheter or mask, by intercostal nerve block with procaine, by aspiration of blood and air from the pleural cavity, and by tracheal aspirations with a catheter. The effect of these measures upon cardio-respiratory imbalance and upon the shock state itself was gratifying in a high proportion of cases. The records of these important methods of promoting stabilization in the preoperative period are incomplete so that the frequency of their application cannot be reported. (For more detailed discussion, see Thoracic Surgery Section, page425.

However, in thoraco-abdominal wounds less time could be devoted to stabilization of the cardio-respiratory physiology than in the purely thoracic cases. Of prime importance in combatting shock, and saving life in thoraco-abdominal wounds was early operative treatment. There is always the probability that contamination of peritoneum and pleura is present, and that with this, continued hemorrhage constitutes the main causes of continued shock and threat to life. Temporizing and delay in bringing these patients to early operation, as soon as replacement therapy had been started, diagnosis established, and measures to combat serious cardi-respiratory imbalance performed, should not be permitted. Even in those patients whose response is poor to adequate treatment, delay in the preoperative tent should ideally never exceed two or a maximum of three hours. The operative procedure itself, with control of respiration under endotracheal anesthesia and tracheal aspiration, closure of the chest and diaphragmatic wounds, and finally, control of hemorrhage and contamination, is the ultimate treatment of shock in these patients. It should not be postponed.

The Thoraco-abdominal Casualty (The Preoperative Period, cont'd).

Further clinical examination of the abdomen was relatively unimportant, and often hard to evaluate, because of referred tenderness and pain with the accompanying chest wound, and rigidity associated with respiratory difficulty. Of importance, however, in the preoperative treatment was the introduction of a nasal stomach tube for aspiration of gastric contents. By this means not only was the stomach drained to minimize vomiting during operation, but also the presence of large amounts of blood in the aspirations was of diagnostic significance. Dilatation of the stomach with air, to such a degree as to be a factor in the embarrassment of respiration, was not an uncommon finding in these patients, and relief, on occasion, was striking, following aspiration. The stomach tube was fixed to remain in place and drain during operation. In addition, an examination of the voided or catherized urine for the presence of blood was made in the preoperative period. This gave valuable information as to the course of the missile in relation to the kidney. Before finishing a discussion of the preoperative period it must be emphasized that in some chest wounds, it was impossible to decide whether or not the diaphragm had been perforated. These cases were treated as any suspected wound of the abdomen, and a thoracotomy performed to explore the diaphragm for perforation.

OPERATIVE PERIOD

With the movement of the casualty from the "shock" tent to the operating tent by stretcher the operative phase of this report is entered. In the majority of instances the patient was operated upon on the stretcher, thus eliminating the awkward, and not harmless procedure of moving a desperately wounded patient at the onset and conclusion of the operation. This phase in the care of the thoraco-abdominal casualty deals with the anesthesia, pathology, operative approach, and procedure.

The average length of time under anesthesia for patients with thoraco-abdominal wounds was slightly over 2½ hours. The majority of inductions were performed with nitrous oxide and oxygen. Ethyl chloride, ether alone or sodium pentothal were employed to induce the patient in a few instances each. In nearly all cases, maintenance anesthesia was achieved by endotracheal ether and oxygen in a closed circuit. This is the anesthesia of choice. It is impossible to overestimate the value of endotracheal anesthesia in operations upon thoraco-abdominal wounds. The anesthetist, who is an expert in the technique of endotracheal anesthesia, must also appreciate the importance of frequent and thorough catheter aspiration of the tracheo-bronchial tree. This was performed before, often during, and always at the termination of the operative procedure. In addition, the value of positive pressure anesthesia, during the period of operation when the thoracic cavity is open, and during closure of the chest when re-expansion of the lung was required, must be stressed.

There should be no hesitation in the use of bronchoscopy where the

The Thoraco-abdominal Casualty (Operative Period, cont'd).

above techniques have failed in effecting re-expansion of the lung and reduction of blood and mucous in the tracheo-bronchial tree. One hundred and ten bronchoscopies are recorded as having been performed at the end of operation in this series of thoraco-abdominal wounds.

Replacement therapy continued during operation consisted of blood transfusions, and infusions of plasma and five percent of glucose in saline. Six hundred and thirty-nine patients received an average of 1000 cc. of blood during operation, in addition, 166 of these were given an average of 575 cc. of plasma each. Seventy eight patients were each given 1000 cc. of 5% glucose in saline during the course of the operative procedure as a supplement to plasma and blood. During 116 operations, no replacement was deemed necessary. One hundred and thirty records do not treat with this point.

Before dealing with the operative approach and procedure in these thoraco-abdominal wounds a discussion of the pathology encountered will be presented.

As stated above, the wound of entrance in the thoraco-abdominal casualty was in the thoracic cage 837 times, as against 66 instances in which the abdomen was the site of entry. In most instances, the injury to the chest wall was associated with fractured ribs. The fractured ribs roughly corresponded to the zone of the diaphragm. In only three instances, of the ribs reported as fractured, was the site above the 6th rib posteriorly or the 4th rib anteriorly. The small size of the target, and the lethal effect of a missile entering the chest to a cephalad direction probably contributed to the pauscity of cases with entry wounds in the upper chest.

Likewise, in most instances the described wound of the lung was in either lower lobe, with some cases of injury to the middle lobe on the right, and the lingula of the upper lobe on the left. The pathology in the lung at these sites was described as "contused", "containing hematoma" or as "perforated" or "lacerated". Because of the path of the missile through the lower part of the chest in the diaphragmatic zone, the peripheral portions of the lower lobes, and less frequently of the middle lobe and lingulm of the left upper lobe, were injured. In some cases with perforation of the costo-phrenic sulcus there was minimal or no lung injury.

The injury to the diaphragm falls roughly into three categories, the single or double small perforating wounds, the large lacerated wounds, and the avulsion of the diaphragm from its chest wall attachment. Similar to the chest wall, the right and left diaphragms were wounded about equally. The right diaphragm was perforated in 436 cases and there were 448 wounds of the left. Both diaphragms were wounded in 20 instances. At the time of operation, evisceration of abdominal contents through the diaphragm was recorded to have occurred in 57 cases. In 17

The Thoraco-abdominal Casualty (Operative Period, cont'd).

instances omentum alone protruded into the pleural cavity, but in 40 cases abdominal viscera were found in the chest.

TABLE IV

Frequency of Perforation of Right and Left Diaphragm with Mortality

	Total Cases	Number Deaths	Percent Mortality
Total Right Diaphragm	435	103	23.6%
Total Left Diaphragm	448	136	30.8%
Total Both Diaphragms	20	8	40.0%
	903	247	

TABLE V

Evisceration of Abdominal Contents Through the Diaphragm Presenting at Operation

Total Number of Cases.................... 57

Number with Evisceration of Omentum Only. 17

	Number Cases	Fatal Cases	Percent Mortality
Evisceration of Abdominal Viscera Through Diaphragm	40	15	37.5%
Through Right Diaphragm	5	2	40.0%
Through Left Diaphragm	35	13	37.1%

The mediastinum was injured in 30 instances. The heart itself was wounded 14 times and the pericardium alone in 13 cases. The esophagus was injured once, and the posterior mediastinum twice.

The Thoraco-abdominal Casualty (Operative Period, cont'd).

TABLE VI

Injuries of the Mediastinum in 903 Thoraco-Abdominal Wounds

Type of Injury	Total	Survived	Died
Ventricular Myocardium and Pericardium	21	8	13
Auricle and Pericardium	1	0	1
Pericardium Only	10	7	3
Esophagus	1	0	1
Posterior Mediastinum	2	1	1
Total	35	16	19

In regard to the pathology in the peritoneal cavity a consideration of the right and left diaphragm with their different underlying anatomical relationship, bears discussion. Wounds of the right diaphragm were associated in 407 out of 436 times with a wound of the liver. The liver, then was the organ which took the impact of the missiles entering through the right diaphragm. After the liver, the following organs in order of froquency were wounded: the right kidney, the colon, the stomach, the small bowel, the duodenum, and the gall bladder. On the left side: the spleen, stomach, and colon were wounded most frequently, and received the impact of most missiles coming through the left diaphragm. In 448 wounds of the left diaphragm, the spleen was injured 272 times, the stomach 167, and the colon in 145 instances. The liver and left kidney were wounded an equal number of times, followed by the small intestine and pancreas, in order of frequency. A comprehensive list of the frequency of organs and combinations of organs wounded is presented from the records (Tables III and IV, Appendix).

The anatomical relationships below the diaphragm have a direct bearing upon the operative approach and procedure on the right and left side. A tabulation of the types of approaches that were used in 903 cases is presented from the records.

The Thoraco-abdominal Casualty (Operative Period, cont'd).

TABLE VII

Method of Operative Approach and Mortality in 903 Thoraco-Abdominal Wounds

	Total	Deaths	Percent Mortality
Thoracotomy Only with Transdiaphragmatic Laparotomy	488	91	20.3%
Laparotomy Only	202	77	38.1%
Thoracotomy, then Laparotomy	144	36	25.0%
Laparotomy, then Thoracotomy	74	26	35.1%
Thoracotomy with Transdiaphragmatic Procedure followed by Laparotomy	20	7	35.0%
Thoracolaparotomy Traversing the Chondral Arch	6	3	50.0%
Non-operated	3	1	33.3%
Died Before End of Operation	6	6	100.0%

Any discussion of methods of approach must be qualified at the onset by saying that no one approach is ideal for all patients, but the judgment of the surgeon, knowing the individual patient, and his own capabilities, will decide the approach to be used by him. In general, where a thoracotomy and laparotomy were both contemplated, the chest procedure was performed first because the patient stood a laparotomy better after the chest wall and diaphragm had been closed and the lung re-expanded. In other words, a more balanced cardio-respiratory system is an important measure in combatting shock, and thoracotomy should be performed before, rather than after a long abdominal procedure.

The practice of stabilizing the chest operatively, by closure of the chest wall and diaphragm, and removal of blood with re-expansion of the lung, before attempting other procedures is a principle of attack about which there can be little disagreement. The question of how much surgery should, or can be done through the chest and diaphragm, and how much through the abdomen, is open to discussion. In this series, 362 cases with thoraco-abdominal wounds had the entire abdominal procedure performed through the diaphragm. In this group, 31 different combinations of organs were operated upon. The mortality of each of these procedures

with the number of cases in each category, is presented (Table V, Appendix). Of the 448 cases with thoracotomy only, 86 cases in which exploration, removal of foreign bodies, or simple retroperitoneal drainage was performed, have not been included.

In further discussion of this topic a consideration of the possibilities of approach when the wound is on the right or on the left side will be debated. Perforating wounds of the chest on the right side, in the upper zone of the diaphragm, are more satisfactorily attacked through a thoracotomy incision, because the diaphragm is much more readily sutured from above than from below. The presenoe of the liver makes adequate exploration and suture difficult and often impossible from below the diaphragm. Similarly, penetrating wounds of the upper zone of the diaphragm, in which the foreign body lies beneath the dome of the diaphragm well within the liver, are more easily handled by the thoracotomy diaphragmatic route. However, on the right side, perforating or penetrating wounds of the lower zone of the diaphragm in the region of the costo phrenic sinus, in which the tract of the missile may well have passed below the liver, should be attacked primarily by a laparotomy approach. Debridement and olosure of the chest wall may be done first or secondly, depending upon the urgency of the suspected abdominal pathology and the amount of respiratory embarrassment present. The diaphragm may be olosed by either route in the region of the oosto phrenic sinus except posteriorly, where closure was difficult and sometimes impossible from the abdominal cavity. Through the transdiaphragmatic approach on the right side, the field of exploration of the abdomen was limited to the superior surface of the liver, the right kidney, and the hepatic flexure of the colon.

On the left side, the problem is somewhat different. The absence of the liver mass, and the relationship of the fundus and body of the stomach, spleen, splenio flexure of colon, body and tail of pancreas, and the left kidney to the inferior surface of the diaphragm not o nly makes for easy accessibility to these organs through the diaphragm, but also permits greater facility of exploration and suture of the diaphragm from below. Wounds of the left diaphragm carry with them the greater threat of contamination of the pleural cavity through the diaphragmatic wound by stomach, colon, and small bowel contents.

The data collected from the records cannot be used to show the superiority of either the laparotomy or the thoracotomy approach separately in these cases. Depending in the individual case upon the magnitude of the abdominal and thoracic problems, the a pproach may be best by thoracotomy or by laparotomy, or by both. It may be said, however, in perforating wounds in the upper zone of the left diaphragm, or in penetrating wounds in which the fragment on X-ray can be demonstrated t o lie within the area of the dome of the diaphragm, that these patients may be treated with facility through the thoracotomy-diaphragmatic

approach. In these cases the expected injury was a perforation of the spleen, stomach, or kidney, all of which organs are accessible to surgery through the diaphragm. Likewise, wounds of the splenic flexure of the colon may be exteriorized in the flank through this exposure. In addition to these organs, it must be stated, that exposure of, and operation upon most of the transverse colon, the upper part of the descending colon and the small intestine from the ligament of Treitz to within 10 inches of the ileo-cecal junction, can be performed through the left diaphragm, depending somewhat upon the habitus of the patient, and the length of the mesenteries.

In those instances of perforation of a hollow abdominal viscus particularly where there is a diaphragmatic wound of any size, a thoracotomy is distinctly of advantage before a laparotomy, in order to cleanse the pleural cavity of gross contamination. In fact, an important part of any thoracotomy entails removal of all foreign material and clot, with a thorough irrigation of the pleural cavity with saline solution. However, in those cases in which a small perforation in the diaphragm is present, and in which contamination is minimal, it must be considered whether it is wise to widely open the diaphragm to attack perforations of hollow organs, thus exposing the pleura and chest wall to wider contamination. These are some of the problems that are met, and which must color the judgment of any surgeon required to meet them.

Further discussion of operative procedure will be limited to the problems peculiar to the thoraco-abdominal wound. Thoracotomies as performed on these cases were of four types: 1) a limited thoracotomy achieved by extending the missile wound, 2) a thoracotomy through the area of the wound, 3) thoracotomy outside the area of the wound, and 4) the thoracolaparotomy incision, in which the thoracotomy was extended through the costal arch and down through the abdominal musculature. In the first category are found those in which the chest wound to be debrided was large, and by simple extension of this wound adequate exposure and suture of the diaphragm could be carried out. In Groups 2 and 3, are the majority of cases. They comprised those in which a formal approach was performed, usually postero-laterally, and either through the rib bed of the ninth rib or the ninth intercostal space. A small proportion of these thoracotomies were performed laterally in the region of the sixth and seventh spaces. Approximately twice as many of these thoracotomies were performed through the intercostal space as through the bed of a rib. The exposure which gave the best approach to transdiaphragmatic work was the postero-lateral one in the region of the ninth or tenth ribs. The transchondral thoracolaparatomy, of which there were six recorded, was used in two cases in which the chondral margin had already been destroyed by the missile. In the four cases in which it was employed as an elective approach one case resulted in a fatal infection, breakdown, and disruption of the wound. Nothing can be said in favor of this type of approach, as an elective procedure.

The Thoraco-abdominal Casualty (Operative Period, cont'd).

In this series of cases, records of procedures performed upon the lung included 80 instances in which lung suture was done, and two instances where a segment of the right lower lobe was excised in a segmental manner. Records of removal of foreign bodies from the lung were found in nine cases.

The method of opening the diaphragm for exposure of abdominal viscera was not specifically stated in the records, more than that the "wound was extended" or in case of two wounds, that they "were connected by incision". As stated above, the missile wound or wounds in the diaphragm were utilized in the performance of a more extended opening in the diaphragm. The direction and extent of incision will depend upon the site of the suspected or known viscera wounded, and the amount of exposure necessary.

The closure of the diaphragm is of utmost importance in these cases, both on the right, and on the left. Suture of the left diaphragm is imperative to cut off the path of contamination and infection from the peritoneal cavity, and to prevent herniation of abdominal viscera into the pleural cavity. It is likewise mandatory to close the right diaphragm to prevent the occurrence of bile pleuritis and empyema, and also to keep contamination and infection from invading the pleural cavity. Even in those instances in which a small fragment has penetrated the liver through the diaphragm, it is conservative to explore, suture the diaphragm, and drain the liver, because it is impossible to estimate in every case the size of the diaphragmatic laceration or liver injury from the size of the missile. In some instances, particularly where a rib has been fragmented in passage of a small missile, it is surprising to find the extent of diaphragmatic and liver laceration.

A firm closure in the greatest proportion of these cases was insured by interrupted silk sutures. In those cases in which the diaphragm was avulsed from the chest wall, it was secured by transplantation and suture at a higher level on the chest wall. A legend of the various methods of closure employed is presented. The phrenic nerve is recorded as having been crushed in 11 instances.

The Thoraco-abdominal Casualty (Operative Period, cont'd).

TABLE VIII

Technique of Suture Used in Closure of the Diaphragm

Interrupted Silk - No statement of number of layers		276
Interrupted Silk - One layer		38
Interrupted Silk - Two layers		61
Interrupted Cotton		66
Combined - Chromic catgut and silk or cotton		21
Interrupted chromic catgut		64
Transplanted:	(Interrupted Silk	6
	(Interrupted chromic catgut	3
	(No record	5
No Suture		39
No Records		267

Discussion of the specific treatment of individual organs of the abdominal cavity is not the province of this report. Suffice it to say that wounds of the stomach and duodenum were sutured, wounds of the colon were exteriorized, wounds of the small bowel treated by suture or by resection and an anastomosis, of the spleen by splenectomy, and of the liver by subcostal drainage. Wounds of the kidney were treated by nephrectomy, only when hemorrhage was persistent, or the pelvis involved, otherwise drainage sufficed. Treatment of the pancreas was by suture and drainage, or by drainage alone.

Detailed complete information in respect to closure of the thoracic wound was not present in the records. In general, closure of the thoracic cage was accomplished by approximation of adjacent ribs or intercostal musculature, depending on whether the thoracotomy was performed through the intercostal space or the bed of a rib. In the case of thoracic wall defects, utilization of contiguous musculature in layers was the usual method employed. Closure of the muscle layers of the chest wall was performed with, or sometimes without closure of subcutaneous tissue and skin. As already emphasized under anesthesia, one of the most important parts of closure is the re-expansion of the lung by the anesthetist utilizing positive pressure. In order to achieve complete exhaustion of air and fluid in the pleural space, either catheter suction just prior to closing the chest, or needle aspiration after closure was useful.

Three hundred and twenty-six cases were recorded as having been drained by a closed water trap intercostal catheter or tube. Either a

large sized fenestrated catheter, or tube of equal caliber, with enough rigidity to prevent it from collapsing, was the available material most commonly used for drainage. The site of drainage was usually the postero-lateral or lateral aspect of the lower chest through a separate intercostal stab wound. In a few instances a small catheter, in addition was placed in the second interspace anteriorly.

The management of the pleural space by drainage or by reliance on aspiration is of prime importance in re-expansion of the lung. A discussion of the question of whether drainage should be required in these thoraco-abdominal wounds, leads to a consideration of the extent of the lung damage, the defect of the chest wall, the magnitude of the diaphragmatic perforation, and the presence of gross contamination from the wound, or particularly, through the diaphragm from a perforated abdominal viscus. Only in those cases in which the thoracic wall defect is small, and in which lung and diaphragmatic injuries are minimal without gross contamination, may water seal intercostal drainage be disregarded as a factor in postoperative expansion of the lung by elimination of pleural blood and air, and control of transient broncho-pleural fistulae. The role of the intercostal catheter drainage in control of pleural infection is that by elimination of the pleural dead space, the process is limited and localized. It is pertinent to stress that the care of the water trap drainage in the postoperative period requires constant vigilance on the part of the surgeon, and a thorough knowledge and conscientious attention on the part of the nursing and corpsman staff of a forward hospital.

THE POSTOPERATIVE PERIOD

The records of the various phases of postoperative care are incomplete in respect to the various details, so that a discussion must be given of the problems encountered. In general, the care of the patient with a thoraco-abdominal wound entails attention to details of care common to both the chest and the abdominal patient.

The complications that were recorded in 656 surviving patients with thoraco-abdominal wounds are presented (Table VI, Appendix). The most frequent complications recorded in order of frequency were atelectasis, empyema, subphrenic abscess and pneumonia. Bronchopleural fistula was recorded four times - twice with empyema and twice with a bile empyema. Pressure pneumothorax occurred in three instances as a postoperative complication.

The postoperative care of the chest is directed towards maintaining cardio-respiratory balance, promoting expansion of the lung, and removal of blood and air from the pleural cavity to allow full expansion and minimize the chances of pleural thrombus formation. When those patients are brought into the postoperative tent, some will need oxygen and additional blood as indicated by cyanosis or signs of peripheral circulatory

failure. As soon as the patient is conscious, he should be started on a regime of frequent turning from side to side, with insistence upon deep breathing and coughing. If the patient cannot, or will not cough, and raise the blood and mucous, intercostal nerve block and tracheal aspiration by catheter should be instituted early and repeated as frequently as is necessary in the presence of atelectatic areas in the lungs, or detectable amounts of blood or mucus in the tracheo-bronchial tree. Often after the first tracheal aspiration the patient will cough and raise without protest. In the event that these methods do not avail in the presence of a pulmonary collapse, bronchoscopy should be employed. There are records of the use of bronchoscopy in 12 instances in the postoperative period. The advantage of the thoracotomy wound alone, without laparotomy, was distinctly appreciated in the postoperative period. The absence of an abdominal incision made for more comfort and for better cooperation from the patient in his important part in lung expansion.

It was the general practice to continue water trap intercostal tube drainage of the chest for two to three days. Often these tubes did not function efficiently for this period, but became sealed off after 24 hours. After removal of the tube on the second or third day, and before, in cases without drainage, aspiration of blood and air was done as indicated, daily if necessary. Often a pocket of air was encountered anteriorly, even in those patients who had a lateral or postero-lateral intercostal tube This was evacuated by aspiration with a needle as soon as detected. Morphine in doses larger than 1/4 grain should not be given to these patients, and its use should not be on a routine basis. One sixth of a grain in many instances sufficed to control the pain in these patients.

A detailed discussion of the postoperative care directed at the abdominal part of the wound will not be entered in this report, except to emphasize the importance of nasal tube stomach siphonage. All these cases particularly with hollow viscus injury should have a nasal tube stomach drainage for varying periods up to four days, depending upon the re-establishment of peristalis to the surgeon's satisfaction. Use of stomach siphonage indiscriminately beyond the period of four days may veil a bowel obstruction, and delay recognition and correction of it.

An accurate knowledge of the daily intake and output of the patients is imperative. During the period in which naso-gastric siphonage was in use between 2000 and 3000 cc. of five percent glucose in saline was given to these patients daily. Caution should be exercised in giving a total amount of parenteral fluids in excess of 3000 cc. daily because of the impaired cardio-respiratory reserve which may exist, and the possibility of producing pulmonary edema. The amount of replacement in blood and plasma given in the postoperative period should be guided by hemoglobin, hematocrit, and serum protein determinations. A normal level should be reached as soon as possible. The routine employment of vitamins B and C in the postoperative period was considered advantageous.

The Thoraco-abdominal Casualty (The Postoperative Period, cont'd).

The use of sulphonamide and penicillin therapy as employed in these cases from the time of wounding through the postoperative period was as follows. Sulphanilamide crystals were placed in the fresh wound in the battalion aid station throughout the entire period. During 1943 and up to May of 1944 sodium sulphadiazine was given parenterally in the postoperative period. After May 1944 penicillin was instituted and was given intramuscularly in doses which varied between 20,000 and 25,000 units at three hour intervals starting in the shock tent and extending through the postoperative period. Before May 1944 three to ten grams of sulfanilamide crystals were placed in the pleural cavity before closure of the chest in most cases and after May 1944 penicillin in amounts ranging from 30,000 to 50,000 units were used similarly in the majority of instances. The use of sulphonamide and penicillin in the abdominal cavity was not as uniform. In most instances their use depended upon the perforation of a hollow viscus. Before May 1944 five to ten grams of sulphanilamide crystals were left in the peritoneal cavity and after May 1944 about one half of the cases still received sulphanilamide crystals, and one half 50,000 units of penicillin intraperitoneally. Due to the lack of follow-up in the survival patient, it is impossible in this report to give any definite data referable to the relative role these drugs played in preventing infection.

Before dealing more fully with mortality, it is pertinent to recognize that the lower mortality rate for these patients in the latter half of 1944, and the year 1945 coincides with the era of penicillin. Without proof, nevertheless, it is considered that this reduction in mortality is a reflection more likely of a greater knowledge and experience in dealing with the problem of the thoraco-abdominal wound as a whole, a greater appreciation of the thoracic implications and complications, a greater experience in facility of the individual surgeon and anesthetist in the operative treatment, and, lastly, a keener appreciation and attention to details of preoperative and postoperative care.

The gross mortality for 903 cases with thoraco-abdominal wounds was 246 or 27.8%. For 1943 the fatalities were 36.7%,for the first six months of 1944, 34.9%, for the last half of that year, 25%, and for 1945 20%. These mortality figures are for deaths in the first priority surgical hospitals, where the usual postoperative residence was from seven to ten days. Some cases remained in this hospital only a few days, while some stayed as long as 18 days.

The Thoraco-abdominal Casualty (The Postoperative Period, cont'd).

TABLE IX

Mortality Rate - 903 Thoraco-Abdominal Wounds - First Priority Surgical Hospital Only

	Total	1943	Jan-Jun 1944	Jul-Dec 1944	1945
Number Cases	903	68	243	392	200
Number Deaths	247	25	84	98	40
Percent Mortality	27.3%	36.7%	34.9%	25.0%	20.0%

It is impossible in the discussion of the mortality data to discover what effect the chest component of the wound had upon mortality except in the case of the wounds injuring the mediastinum. The mortality when this part of the chest was wounded was 54%.

However, the most lethal part of the thoraco-abdominal wound was the abdominal portion. Roughly, the type of organ and number of organs wounded below the diaphragm were reflected in the mortality rate. Wounds involving five or more different organs were universally fatal.

The mortality rate of all abdominal wounds in the first priority surgical hospitals as compared to the thoraco-abdominal wound is of interest. In abdominal wounds of all types there was a mortality rate of 24.1%, in the thoraco-abdominal wound the rate was 27.3%. This covers the entire period of 1943, 1944 and 1945 in the case records of the 2nd Auxiliary Surgical Group.

The cause of death and postoperative day on which death occurred were recorded in 234 out of 247 fatalities. Shock was given as the most frequent cause of death on the operating table, the day of operation, and the first postoperative day. Four cases were recorded as having died on the operating table of hemorrhage. However, in the so-called shock death, blood loss was a contributory factor, as were overwhelming contamination and infection of the peritoneal and pleural cavities and retroperitoneal space, disturbance of cardio-respiratory physiology, and massive tissue destruction. In 15 cases renal failure as expressed in oliguria and anuria was the cause of death most commonly encountered from the third to the fifth day postoperative. Peritonitis and pneumonia were the next most frequent causes of fatalities respectively, (Table VII, Appendix).

In nine cases, death was considered to have been due to the effect of an associated injury rather than as a result of the thoraco-abdominal wound. The role of the associated wound in the morbidity of these pat-

ients is an important factor. Lesions of the spinal cord, produced by the missile of the thoraco-abdominal wounds, have been considered as associated wounds. There were 95 severe, 129 moderate, and 161 mild associated wounds. The types of wounds in the severe category are stated (Table VIII, Appendix). The moderate group included fractures of long bones other than the femur, and multiple wounds of less serious nature than those of the severe category. Flesh wounds and those involving fractures of the hand and foot are listed under mild wounds.

SUMMARY

1. Available data in 903 thoraco-abdominal cases have been presented from the records of the 2nd Auxiliary Surgical Group during 1943, 1944, and 1945. Thoraco-abdominal wounds comprised 25.5% of all abdominal wounds operated upon by the surgical teams of the Group.

2. Topics not covered by recorded data have been discussed from the point of view of practice.

3. An attempt has been made to give an accurate picture of the patient with a thoraco-abdominal wound through the period of treatment in forward hospitals.

CONCLUSIONS

1. Recognition of perforating wounds of the diaphragm in chest and abdominal casualties is of prime importance.

2. The value of correction of altered cardio-respiratory physiology in the preoperative period, of endotracheal anesthesia during the operation, and of re-expansion of the lung at operation and postoperatively cannot be overestimated in the treatment of these patients.

3. The importance of early operation because of the abdominal wound, and of initial control of the thoracic pathology at operation upon the thoraco-abdominal wound is shown.

4. The transdiaphragmatic procedure alone is a satisfactory method of approach in certain types of thoraco-abdominal wounds as demonstrated by the results of 362 procedures.

5. The reduction in the mortality of thoraco-abdominal wounds from 36.7% in 1943 to 20% in 1945 in forward hospitals is the result of a fuller understanding of the problems of the thoraco-abdominal wound as a whole, of its thoracic implications in particular, of a wider experience of the individual surgeon and anesthetist, and of a keener appreciation of the essentials of preoperative care and postoperative care. The role of penicillin cannot be estimated.

The Thoraco-abdominal Casualty, cont'd.

APPENDIX

TABLE I

Causative Agent

Shell Fragment Wound	Gunshot Wound	Mine Fragment Wound	Bomb Fragment Wound	Grenade Fragment Wound	No Record
590	245	34	6	4	24

TABLE II

Site of Injury in 903 Thoraco-Abdominal Wounds

Wound of Entry	Diaphragm Involved	Total
Right Chest	Right Diaphragm	405
Right Chest	Left Diaphragm	6
Right Chest	Both Diaphragms	7
Right Abdomen	Right Diaphragm	18
Right Abdomen	Left Diaphragm	12
Left Chest	Left Diaphragm	403
Left Chest	Right Diaphragm	3
Left Chest	Both Diaphragms	13
Left Abdomen	Left Diaphragm	27
Left Abdomen	Right Diaphragm	9
Total		903

The Thoraco-abdominal Casualty, (Appendix, cont'd).

TABLE III

Total Times Each Organ Was Involved Without Reference to Combination With Other Organs

	Right Diaphragm		Left Diaphragm		Both Diaphragms	
	Total Cases	Fatal	Total Cases	Fatal	Total Cases	Fatal
Liver	407	96	82	34	18	7
Spleen	2	1	272	17	5	2
Right Kidney	84	33	5	2	0	0
Left Kidney	0	0	82	36	0	0
Pancreas	6	4	26	11	1	1
Adrenal	1	0	2	0	0	0
Stomach	32	17	167	71	12	5
Duodenum	17	12	2	1	0	0
Jejunum	11	7	62	29	1	0
Ilium	13	4	9	1	0	0
Cecum	3	1	0	0	0	0
Ascending Colon	8	6	2	2	0	0
Hepatic Flexure	18	13	4	2	0	0
Transverse Colon	13	8	62	26	1	0
Splenic Flexure	2	1	54	28	1	1
Descending Colon	0	0	23	8	0	0
Gall Bladder	12	9	0	0	1	1
Common Duct	2	2	0	0	0	0
Portal Vein	1	1	0	0	0	0
Ureter	0	0	1	1	0	0
Vena Cava	4	4	1	1	0	0

The Thoraco-abdominal Casualty, (Appendix, cont'd).

TABLE IV

Frequency of Wounding and Mortality of Viscera and Combination of Viscera in 903 Thoraco-Abdominal Wounds

	Total Cases	Fatal Cases	Percent Mortality
Liver	297	35	11.7%
Spleen	95	10	10.5%
Liver and Kidney	59	14	23.7%
Spleen and Stomach	43	18	41.8%
Liver and Stomach	30	11	36.6%
Peritoneal Cavity Only	26	3	11.5%
Spleen, Kidney	27	4	14.8%
Spleen and Left Colon	19	4	21.0%
Left Colon	18	6	33.3%
Spleen, Kidney and Left Colon	12	6	50.0%
Liver, Spleen and Stomach	11	3	27.2%
Spleen, Stomach and Left Colon	8	4	50.0%
Spleen, Kidney and Stomach	9	3	33.3%
Liver and Small Intestines	9	1	11.1%
Liver, Stomach and Colon	8	5	62.6%
Liver, Kidney and Right Colon	5	4	80.0%
Liver, Small Intestine, Left Colon	6	5	83.3%
Liver, Stomach, Biliary Tract	6	4	66.6%
Kidney	11	4	36.6%
Stomach and Left Colon	8	2	25.0%
Spleen and Small Intestine	9	0	0.0%
Liver and Spleen	7	3	42.8%
Stomach, Small Intestine, Colon	8	2	25.0%
Small Intestine, Left Colon	6	3	50.0%
Liver and Right Colon	7	4	57.1%
Kidney and Stomach	4	1	25.0%
Liver and Left Colon	3	1	33.3%
Spleen, Stomach and Pancreas	3	2	66.6%
All Other Combinations (62 in all mortality of five organs or more - 100%)	115	73	63.4%

The Thoraco-abdominal Casualty, (Appendix, cont'd).

TABLE V

31 Transdiaphragmatic Procedures in Which Thoracotomy Alone was Employed

Procedure	Total Cases	Fatal Cases	Percent Mortality
Liver Drainage	148	17	11.4%
Splenectomy	87	9	10.3%
Splenectomy and Stomach Suture	27	12	44.4%
Stomach Suture	23	5	21.7%
Colostomy (left colon flank colostomy)	12	3	25.0%
Splenectomy and Colostomy	10	3	30.0%
Stomach Suture and Liver Drainage	7	5	
Splenectomy, Colostomy and Jejunal Repair	6	3	
Right Nephrectomy and Liver Drainage	6	2	
Left Nephrectomy and Splenectomy	5	0	
Splenectomy, Stomach Suture, and Liver Drainage	4	1	
Splenectomy, Stomach Suture and Colostomy	3	1	
Stomach Suture and Colostomy	3	3	
Splenectomy and Jejunal Anastomosis	2	1	
Splenectomy, Stomach and Pancreas Sutured	2	1	
Splenectomy and Liver Drainage	2	0	
Jejunal Repair	1	0	
Left Nephrectomy, Stomach and Jejunal Repair	1	0	
Stomach Suture, Colostomy and Liver Drainage	1	0	
Left Nephrectomy, Splenectomy and Colostomy	1	0	
Left Nephrectomy and Stomach Suture	1	1	
Stomach Suture, Colostomy and Liver Drainage	1	0	
Left Nephrectomy, Splenectomy and Stomach Suture	1	1	
Stomach and Small Intestine Suture and Colostomy	1	1	
Jejunal Suture, Colostomy and Liver Drainage	1	1	
Stomach and Jejunal Suture	1	1	
Splenectomy, Stomach Suture, Colostomy and Liver Drainage	1	0	
Left Nephrectomy	1	0	
Left Nephrectomy and Stomach Suture and Colostomy	1	1	
Colostomy and Liver Drainage	1	0	
Left Nephrectomy, Jejunal Suture and Colostomy	1	0	
TOTAL	362	72	19.9%

The Thoraco-abdominal Casualty, (Appendix, cont'd).

TABLE VI

Recorded Complioations in 656 Thoraco-Abdominal Wounds - Survival Cases

	Number of Cases
Atalectasis	21
Empyema	17
Empyema with Bronchopleural Fistula	2
Subphrenic Abscess	15
Pneumonia	12
Abdominal Wound Disruption	7
Abdominal Wound Disruption with Evisceration	3
Bile Empyema	5
Bile Empyema with Bronchopleural Fistula	2
Chest Wound Infection and Breakdown	8
Intestinal Obstruction	5
Persistent Pleural Effusion	5
Tension Pneumothorax	3
Jaundice	3
Incomplete Expansion of Lung	2
Oliguria	2
Gastric Hemorrhage	2
Chest Wall and Diaphragm Breakdown	1
Psychotic State	5
Leg Vein Thrombosis	2
Hepatic Abscess	1
Pelvic Abscess	1
Pulmonary Edema	1
Hemorrhage from Thoracotomy Wound	1
Pulmonary Embolism	1
No Complications Recorded	364
No Records	165
TOTAL	656

Mortality - Time Postoperatively and Primary Cause of Death
247 Deaths - 18 Cases No Records

	Number of Deaths	Shock	Hemorrhage	"Renal Failure" Oliguria and Anuria	Atalectasis	Pneumonia	HT. Tamponade or Injury	Peritonitis	Missed Perforation	Peritonitis and Pleuritis	Pulmonary Embolus	Mis-Matched Blood	Blast	Mediastinitis	Fat Embolism	B-P Fistula (Pressure Pneumothorax)	Liver Deaths	Gas Infection	Disruption Diaphragm	Morphinism	Bronchoscopy	Meningitis	Liver Abscess	Empyema
On operating Table	49	40	4		3		1														1			
Operative Day	76	59					2	6	2	2	1	1	2							1				
1st P.O. Day	29	18			1	2		2		2	2		1	1										
2nd P.O. Day	28	12			1	7		4			2				1							1		
3rd P.O. Day	12	1		5	2			1			1					2								
4th P.O. Day	9			4		3											1	1						
5th P.O. Day	7			4		1		2																
6th P.O. Day	7					2		1			1							1	1					1
7th P.O. Day	6			1		2		1			1													1
8th P.O. Day	3							1																2
9th P.O. Day	3			1							1												1	
10th P.O. Day	2							1			1													
11th P.O. Day	0																							
12th P.O. Day	0																							
13th P.O. Day	2							1																1
14th P.O. Day	1																		1					
	234	130	4	15	7	17	3	20	2	4	10	1	3	1	1	2	1	2	2	1	1	1	1	5

The Thoraco-abdominal Casualty, (Appendix, cont'd).

TABLE VIII

Associated Wounds - Degree and Frequence with Mortality

	Total Cases	Fatal Cases	Percent Mortality
Severe			
Cord Injury	26	16	
Brain Injury	7	1	
Fracture of Femur	15	4	
Other Chest Wound	6	0	
Other Abdominal Wound	8	4	
Traumatic Amputation:			
Arm	5	1	
Leg	4	2	
Thigh	0	0	
Multiple Severe Wounds	24	8	
Total	95	36	37.8%
Moderate	129	33	25.5%
Mild	161	34	21.4%
TOTAL	385	103	26.7%

AMPUTATIONS

GENERAL CONSIDERATIONS

This report covers the amputations done by teams of the 2nd Auxiliary Surgical Group during the following campaigns: Algeria-French Morocco, Tunisian, Sicilian, Naples-Foggia, Rome-Arno, North Appennines, Po Valley, Southern France, Rhineland and Central Europe. A total of 1358 amputations were performed in 1235 cases. Of these, 227 amputations in 207 cases were of digits or portions of digits. The remainder, 1131 amputations in 1028 cases, form the basis of this report.

Seven hundred and forty cases were done in Field Hospitals. The Field Hospital in which surgical teams of the Group functioned as first priority surgical hospitals, set up in the vicinity of a Division Clearing Station. Two hundred and six amputations were performed in Evacuation Hospitals and only 22 amputations were carried out by member of this Group functioning in Base Hospitals.

TABLE I

Installations in which Amputations (Fingers and Toes Excluded) Were Performed

Field Hospital	740
Evacuation Hospital	206
Casualty Clearing Station (British)	46
Clearing Station	14
Station Hospital	13
Civilian Hospital	6
General Hospital	3
Total	1,028 Cases

The average lapse of time from wounding to surgery was 11.98 hours for patients suffering no other major injuries. For battle casualties with major amputations and no other serious injuries, who followed the chain of evacuation, the average time lag was 9.75 hours from wounding to surgery if done in a Field Hospital; 14.75 hours if done in an Evacuation Hospital. The latter figure reflects the fact that surgical teams were generally used in evacuation hospitals during times of stress.

AGE OF PATIENT

The average of the soldier patients was 24.7 years. Eighty amputations were performed on civilians, who age ranged from six to 59 years.

DEFINITION OF TYPES

For the purpose of analysis the cases were divided into primary traumatic amputations and those secondary to other wounds. Cases in which the original injury completely severed the extremity or portion

Amputations. (Definition of Types, contd).

thereof and those in which the part remained attached only by skin, fascia, or a strip of devitalized muscle were considered as primary traumatic amputations. Those in which the extremity was rendered non-visible due to one of two things - interruption of blood supply or overwhelming infection were classed as amputations secondary to other wounds.

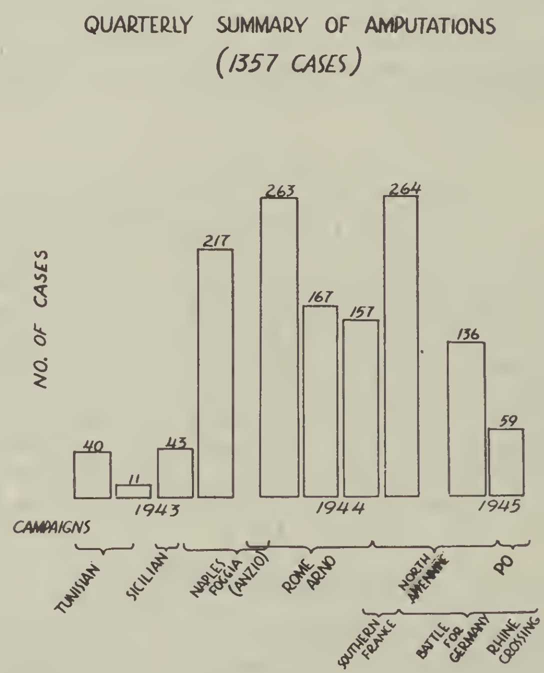

Figure 91 - Quarterly Summary of Amputations.

Amputations. (Definition of Types, contd).

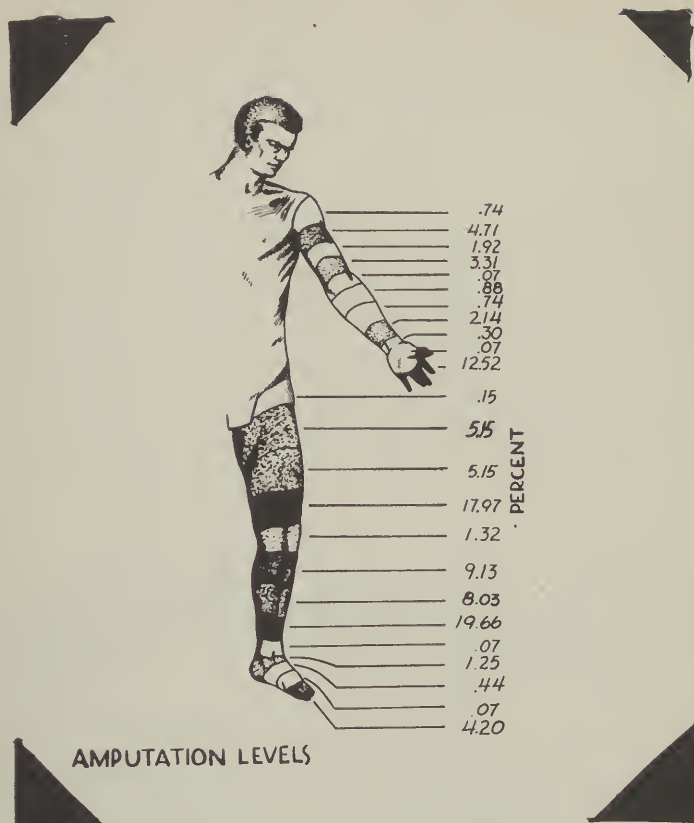

Figure 92 - Levels of Amputations.

TABLE II

Types of Major Amputations

	No. Cases
Primary Traumatic	768
Secondary to Vascular Injury	152
Secondary to Sepsis	108
TOTAL	1028

Amputations. (Definition of Types, contd).

TABLE III

Causative Agents

	No. Cases	Pct. Mortality
Shell Fragments	572	54.9%
Mine	334	32.1%
Small Arms	47	4.5%
Hand Grenade	25	2.4%
Bomb	23	2.2%
Booby Trap	19	1.8%
Accidents, Auto, Etc.,	10	1.0%
Others	12	1.1%

Figure 93 - Photograph of a Double Thigh Amputation Caused by a Land Mine.

Amputations.

CAUSATIVE AGENTS

Amputations caused by certain agents presented characteristics sufficiently uniform to warrant description of a typical case.

Mines.

Anti-personnel mines were of several different types. The common one consisted of an explosive charge buried superficially in the ground. It was detonated when stepped on. Thus, the typical "mine amputation" found in cases which survived to reach a surgical installation was one in which a portion of one or both lower extremities was completely blown off, or one completely amputated with severe wounds in the other. The face or buttocks were splattered with perforating wounds. Dirt, bits of clothing, and chunks of a characteristic grey-green putty-like material were driven several inches into the stumps. Stripping of the periosteum and muscles from the bone end was apt to be severe. The stumps smelled of burned flesh. Irregular clumps of blackened muscle and fascia sometimes hung from the stump ends. The skin on the remaining portion of the amputated extremity and on a surviving extremity was apt to be peppered with perforating wounds.

Shell Fragments.

Mortar shells have sometimes caused the same burning of tissues in an amputation stump as was seen in those caused by mines. In those caused by larger shells this has usually been absent. Clothing and grass have often been found in the stumps. Maceration of muscle tissue was always present but varied considerably in degree.

Hand Grenades.

The only thing remarkable about amputations caused by hand grenades was the unusually large amount of non-metallic foreign material - clothing, etc., - found in the immediate vicinity of a buried grenade fragment and scattered along its wound tract.

MULTIPLE AMPUTATIONS

Double Amputations.

A total of 95 double amputations were done. Of these 95 cases, 15 were complicated by other major injuries. Of the 80 cases uncomplicated by other major injuries 12 died while under the care of the surgical teams, giving an observed mortality rate of 15%.

Amputations. (Multiple Amputations, contd).

Eight cases of double amputations of the thighs or legs and no other major injuries were admitted with a blood pressure of 0/0. Seven of these survived to be evacuated.

Triple Amputations.

A total of four cases had triple amputations performed. Two died while under the observation of the surgical teams. The two who survived had perceptible blood pressures when admitted; the two who did not, died.

DISARTICULATIONS

TABLE IV

The total number of disarticulations done were as follows:

	No. Cases
Tarso-Metatarsal	6
Mid-Tarsal	17
Ankle	1
Knee	18
Hip	2
Wrist	4
Elbow	1
Shoulder	10
TOTAL	59

Most disarticulations fell into disfavor due to complaints report from the Base Hospitals. The principal difficulty encountered in the immediate postoperative care of disarticulations was the severe pain that sometimes occurred, probably due to the drying of the exposed cartilage. Certainly, it could be relieved by section of the bone end proximal to the cartilage.

TREATMENT RECEIVED PRIOR TO ADMISSION TO A SURGICAL INSTALLATION

Tourniquets.

Most patients who were seen with major amputations showed evidence of marked blood loss on admission. Division medical personnel reduced this loss by means of pressure dressings and tourniquets. Web cloth tourniquets were commonly used. Even when applied at the site of pre-

ference for tourniquets - as they usually were - they did not always completely control hemorrhage. The use of rubber tourniquets was limited. Cases have been admitted in which a strong rubber tourniquet had been placed immediately proximal to the traumatic amputation site. This appeared to be a satisfactory measure in patients having a devitalized stump end. In only one case record was mention made of the possibility of a tourniquet being responsible for amputation at a higher level than would have otherwise been necessary. In this instance it was by no means certain that the tourniquet was at fault.

Morphine.

There were 12 cases in which signs and symptoms of acute morphine intoxication were recorded. Six of these were classed as moderate on the basis of sluggishness, semi-consciousness, moderate depression of respiration and pin point pupils. Six were classed as severe on the basis of marked respiratory depression requiring stimulants or artifical respiration. No deaths were directly attributable to morphine. In nine case records one grain was recorded as having been given prior to admission.

Splints.

The use of splints for complete amputations was not common. When the extremity was still attached, a splint prevented tugging by the lifeless portion during transportation. In some instances where the amputation was complete except for strands of fascia or a tendon, these were advantageously severed in the Battalion Aid Station.

Plasma.

In calculating the average amount of plasma given to amputation cases before admission to a surgical installation, those patients who had other major injuries were excluded. Specifically, concomitant, intracranial, intrathoracic, intra-abdominal injuries and compound fractures of long bones were excluded. Four hundred and ninety case records of amputations were selected on this basis. The average quantity of plasma received by these patients was 2.54 units or 635 c.c.

Blood.

One hundred case records of amputations without other major injuries indicated that blood was given before admission to a Field or Evacuation Hospital. These 100 cases received an average of 2.29 units, or 1,145 c.c. of blood.

Amputations.

SHOCK IN AMPUTATION CASES

It was recognized that blood pressure was not the sole criterion of shock nor always a reliable one. However, the evaluations of the degree of shock made by a number of different observers did not lend themselves to statistical study. Suffice it to state that all patients with major amputations exhibited some degree of shock. The degree of shock was less in cases which had the more sharply demarcated stumps. The most severe states of shock were found in those patients who sustained severe injuries to an extremity with interruption of the main blood supply but with some collateral circulation present, not enough to maintain viability for any length of time.

As an example of the common problem of shock in amputation cases, the average patient with an amputation through the distal third of the thigh presented the following picture: His blood pressure was about 60/30. His pulse was thready and ranged around 120. His hands were definitely cold. Marked pallor was evident in the face, especially in the lips and conjunctiva. The skin was dry. His saliva was viscid. He was apathetic and seldom complained of pain. His response to questioning was slow and labored. He remembered details of what he was doing at the time of injury but was apt to be hazy about what happened after that. He went to sleep readily. When aroused he invariably asked for a drink of water.

Forty-one case records of patients with amputations and no other major injuries indicated that they had no obtainable blood pressure on admission. Seven of these died while under the observation of the surgical teams giving an observed mortality rate of 17%.

BLOOD PRESSURE AND PULSE AVERAGES IN AMPUTATIONS

Cases with no other injuries apt to influence the blood pressure and pulse were selected for these averages.

The number of cases on which each average was based is placed in parenthesis.

TABLE V

1. Average Blood Pressures and Pulses of All Uncomplicated Cases.

	Blood Pressure	Pulse
Admission	81/45 (244)	115 (91)
Before Operation	116/69 (640)	117 (365)
Low During Operation	91/52 (296)	120 (132)
Close of Operation	104/60 (378)	117 (202)

Amputations. (Table V, contd).

2. Leg.

	Blood Pressure		Pulse	
Admission	92/52	(108)	112	(42)
Before Operation	119/70	(312)	115	(170
Low During Operation	98/57	(151)	118	(61)
Close of Operation	108/62	(187)	114	(93)

3. Thigh.

Admission	74/40	(99)	120	(38)
Before Operation	112/68	(214)	122	(121)
Low During Operation	83/47	(110)	124	(54)
Close of Operation	99/58	(136)	120	(78)

4. Forearm.

Admission	75/48	(6)	84	(1)
Before Operation	120/72	(28)	102	(14)
Low During Operation	77/46	(6)	110	(3)
Close of Operation	92/54	(8)	100	(4)

5. Arm.

Admission	72/43	(26)	108	(9)
Before Operation	116/69	(72)	112	(41)
Low During Operation	88/50	(19)	118	(9)
Close of Operation	106/61	(34)	115	(18)

6. Shoulder Disarticulation.

Admission	-		-	
Before Operation	96/58	(6)	140	(3)
Low During Operation	-		-	
Close of Operation	94/50	(4)	105	(2)

7. Knee Disarticulation.

Admission	-		-	
Before Operation	108/69	(8)	129	(7)
Low During Operation	83/50	(8)	130	(4)
Close of Operation	94/56	(9)	125	(7)

SHOCK THERAPY

Shock in amputation cases usually responded well to rest, plasma and blood. When a patient was admitted, plasma was started immediately and kept going until cross-matched blood was available. In the more

Amputations. (Shock Therapy, contd).

critical patients at least part of the fluid replacement was administered under pressure. At the end of an hour the blood pressure had usually begun to rise.

PLASMA ADMINISTERED IN THE SHOCK WARD PREOPERATIVELY

TABLE VI

	Units	Based on No. Cases
Shoulder Disarticulation	3.00	2
Arm	2.09	33
Forearm	1.90	12
Hand	0.00	1
Thigh, Proximal Third	2.52	19
Thigh, Middle Third	1.76	17
Thigh, Distal Third	2.23	59
Knee Disarticulation	2.66	6
Leg, Proximal Third	2.10	28
Leg, Middle Third	2.26	30
Leg, Distal Third	1.93	48
Portion of Foot	1.20	5

BLOOD ADMINISTERED IN THE SHOCK WARD PREOPERATIVELY

TABLE VII

	Units	Based on No. Cases
Shoulder Disarticulation	1.5	3
Arm	2.38	44
Forearm	1.33	12
Hand	4.00	1
Thigh, Proximal Third	2.80	35
Thigh, Middle Third	2.66	24
Thigh, Distal Third	2.76	98
Knee Disarticulation	2.25	4
Leg, Proximal Third	1.88	43
Leg, Middle Third	1.77	45
Leg, Distal Third	1.85	88
Portion of Foot	1.75	4

The average time a patient was kept in the shock ward of a Field Hospital was four and one-half hours. In an Evacuation Hospital it was nine hours. During this time he was given an average of 492 c.c. of plasma and 1,120

Amputations. (Shock Therapy, contd).

c.c. of blood. The average blood pressure rose from 81/45 to 116/69 during this interval.

The admission to surgery time lag of nine hours in Evacuation Hospitals, averaged from Auxiliary Surgical Group team records, reflects the fact that the teams were used largely in times of stress by these hospitals. Even the Field Hospital time of four and one-half hours does not reflect the minimum time necessary to prepare the average amputation case for surgery. This has often been accomplished in one to two hours. The simultaneous presence of higher priority cases in the shock ward has tended to lengthen the time spent there by patients with amputations.

Some cases have required the arrest of hemorrhage after admission to the shock ward. This was accomplished by means of tourniquets and pressure dressings. Recurrence of bleeding with the rise of blood pressure was rare.

Few patients complained of pain. When they did, attempts were made to relieve it by adjusting the dressings and by the use of morphine.

The application of external heat was felt to be of value only when the tent was so cold that the shocked patient would shiver or complain of the cold. The heat was applied by means of warmed blankets or hot water bottles.

In severely shocked patients, who showed little or no response to fluid replacement, the application of a strong rubber tourniquet has sometimes been followed by a rise in blood pressure. When the site of the amputation precluded the use of a tourniquet a rapid guillotine amputation was done without further delay. Some of these responded favorably and made uneventful recoveries.

BEHAVIOR OF THE BLOOD PRESSURE DURING OPERATION

Ordinarily, the patient was not considered to be ready for operation until the systolic blood pressure had exceeded 100 mm. and had become stabilized. Operative intervention was felt to be indicated at any time the blood pressure ceased to continue its rise or began to fall in spite of attempts at resuscitation.

The alert anesthetist learned to anticipate drops in pressure and prepared for them ahead of time by having a large bore needle or cannula in one or more veins, cross-matched blood within arm's reach and apparatus at hand for giving blood under pressure if the need arose.

Amputations. (Behavior of the Blood Pressure During Operation, contd).

A slight drop occurred during the induction phase of anesthesia. A further drop came with the skin preparation of areas inaccesible prior to anesthesia. Where advisable, the latter drop was controlled by the application of a surgically effective tourniquet prior to the preparation. The blood pressure became stabilized, in fact would often rise, following the application of a tourniquet. When released after amputation, there would be an immediate drop of up to 20 mm. in the systolic pressure. These fluctuations were more pronounced in patients who had had inadequate fluid replacement.

The following case illustrated fluctuations of blood pressure:

W. S. - American Soldier, Age - 21.

Diagnosis.

1. Amputation, traumatic, incomplete, right leg, middle third.
2. Fracture, compound, comminuted, tibia, left, middle third, with three inch bony loss.
3. Fracture, compound, comminuted, fibula, left, middle third.
4. Laceration, complete, anterior tibial artery and vein, left.

History.

Wounded in action, shell fragments, 1400 hours, 9 January 1945. At 1445 hours he was given one-fourth grain of morphine. Sterile dressings and short basswood splints were applied to both legs. At 1615 hours he was given 500 c.c. of plasma and four grams of sulfadiazine.

Physical.

The patient was in shock. Blood pressure 60/40. Marked pallor was present. He responded sluggishly to questioning. The right leg was amputated in the middle third except for a strip of skin anteriorly and a band of muscle and skin posteriorly. A wound about three inches in diameter passed from one side of the left calf to the other in the middle third. The basswood splints did not immobilize the fractures or prevent tugging by the partially amputated leg.

Preoperative Treatment.

Two hundred and fifty c.c. of plasma and 500 c.c. of blood were given. The pressure rose rapidly to 120/80. He was carefully taken to X-ray which was in an adjoining room. The X-ray films were slipped under the legs just as they lay. No attempt was made to get lateral views. Thence, he was carried to surgery - a distance of less than 15 feet. He was left on the litter. No recurrence of bleeding was noted. During

Amputations. (Behavior of the Blood Pressure During Operation, contd).

this minimum of handling his systolic pressure had dropped to 60. Five hundred c.c. of blood were given over a period of one hour, during which time he was allowed to lie still. The blood pressure rose to 90/60. Anesthesia started.

Operation: 2105 hours, 9 January 1945.

Oxygen ether anesthesia was used. Another 500 c.c. bottle of blood was started. As soon as the patient was anesthetized tourniquets were applied high on both thighs and skin preparation of the legs completed. This involved lifting both legs to wash and shave the posterior aspects. During the preparation the blood pressure rose to 100/60. A circular flapless guillotine amputation of the right leg in the middle third was performed. On release of the tourniquet the blood pressure fell suddenly from 100/60 to 80/60. The wound of the left leg was then debrided. Anterior tibial artery and vein ligated. Tourniquet released. The blood pressure dropped from 80/60 to 60/30. During the application of the cast to the left lower extremity and Thomas splint to the amputation, the pressure fell to 40/0 although the remainder of the bottle of blood was being given under pressure. While the plaster was setting the blood pressure rose to 100/50. He was left in surgery another 30 minutes for observation, during which time the blood pressure rose to 110/60. Removal to the ward did not cause another fluctuation.

Progress.

Convalescence was uneventful during the period observed. He did not remember being admitted to the hospital or anything that transpired in the shock ward. He was given a total of 2,000 c.c. of blood over a period of two days, at the end of which time his red cell count was 3,860,000, hemoglobin (Sahli) 11.5 grms. He was given another 500 c.c. of blood, the dressing changed on the stump and a traction cast substituted for the Thomas splint. Evacuated on the fourth postoperative day.

This case has been selected to illustrate the variations in blood pressure because the fluctuations were marked. Patients with more complete fluid replacement preoperatively often showed similar changes but were less pronounced.

TIME LAG IN AMPUTATION CASES

These averages were calculated from cases not complicated by other major injuries. The average for all these cases in which time lags could be calculated were:

Amputations. (Time Lag in Amputation Cases, contd).

TABLE VIII

Time Lag, All Cases

	Hours	No. of Cases Average is Based On
Wounding to Admission	6.88	73
Admission to Surgery	3.83	73
Wounding to Surgery	11.98	733

To gain more accurate information regarding the time lag of battle casualties, these were selected and averages calculated. Eight battle casualties were omitted because of unuaual circumstances. For instance, one paratrooper was not rescued until 5 days after wounding. The other seven cases had the following wounding to admission times: 72, 72, 72, 90, 63, 64, 67 hours.

TABLE IX

Time Lag, Battle Casualties

	Field Hospital		Evacuation Hospital	
	Hours	Cases	Hours	Cases
Wounding to Admission	5½	79	10½	10
Admission to Surgery	4½	81	9	10
Wounding to Surgery	9-3/4	597	14-3/4	161

ANESTHETIC AGENTS

The anesthesia preferred by most anesthetists was nitrous oxide, oxygen, ether. When this was not available drop ether with or without ethyl chloride for induction was used. As time went on ethyl chloride fell into disfavor. Shocked patients were given oxygen throughout the operation. Spinal anesthesia was used a few times early in the war but was soon discontinued. Pentothal was sometimes used for lesser amputations. It was found to be a satisfactory agent. Endotracheal anesthesia became increasingly popular as the war progressed. Local or nerve block anesthesia was not used.

OPERATION TECHNIQUE

Severely shocked patients were left on the litter for operation. If not already going, blood or plasma was started intravenously. Anesthesia was started. When the extremity was still attached by a few shreds of

Amputations. (Operation Technique, contd).

fascia or skin these were severed and the extremity removed. Frequently it was impossible to shave the posterior aspect of the stump prior to anesthesia. Usually a towel was placed around the extremity for padding and a tourniquet applied. An ordinary blood pressure apparatus was found to be satisfactory for the upper extremity provided it was fixed in place with roller bandage, pumped up to 250 mm. and both tubes leading from the cuff clamped. Some surgeons preferred to work without a tourniquet.

Skin preparation consisted of soap and water followed by tincture of iodine or one of the mercurial antiseptics.

The site for amputation was the lowest possible level of viability regardless of the utility of the stump. When there was any question as to this level, serial circular incisions were made until a debridable level was reached. The ever-present plasma box was used under the sterile drapes to prop up the extremity.

The flapless guillotine amputation was the standard procedure. The technique for the performance of amputations is as follows: A circular incision is made through the skin at the lowest level compatible with viable tissue and the skin allowed to retract; the fascia is then incised at the level to which the skin has retracted. The superficial layer of muscle is then cut at the end of the fascia and permitted to retract. At its point of retraction, the deep layers of muscle are cut through to the bone. After the deep muscles have retracted, the periosteum of the bone is cleanly incised and the bone sawed through flush with the muscles. No cuff of periosteum is removed as in a closed amputation. Bone denuded of periosteum will sequestrate if infection is present and a ring sequestrum often results when the periosteum has been removed. It is important also that no periosteum be elevated or torn from the bone in the stump by rough handling. The properly performed flapless guillotine stump exhibits a slightly concave open cross section of the extremity.

Lacerations of the stump were not sutured but pulled together and excessive gaping prevented during the application of the stockinette.

Vaseline gauze strips were laid over the stump end and fluffed gauze applied. Toward the end of the hostilities in Europe vaseline gauze was more and more replaced by dry fine mesh gauze. The skin edge and a bit of the fluffed gauze were grasped in four to six places with towel clamps. The stump was held up by these while the skin was dried with ether and "Ace Adherent" applied. The stockinette was then placed over the operator's hand and lay in a small roll around his wrist. He grasped the towel clamps with this hand. The stockinette was then

Amputations. (Operation Technique, contd).

easily slid over the hand, towel clamps and dressing and rolled on to the stump. This method of applying the stockinette was more rapid and less apt to stir up ooze than if no towel clamps were used. A spreader was placed inside the stockinette.

When there had been considerable blast injury to the stump, copious serous drainage occurred during the first two or three days. If this were anticipated, the application of a traction cast was delayed until it had subsided, the stump meanwhile being bandaged in a Thomas splint with elastic traction attached.

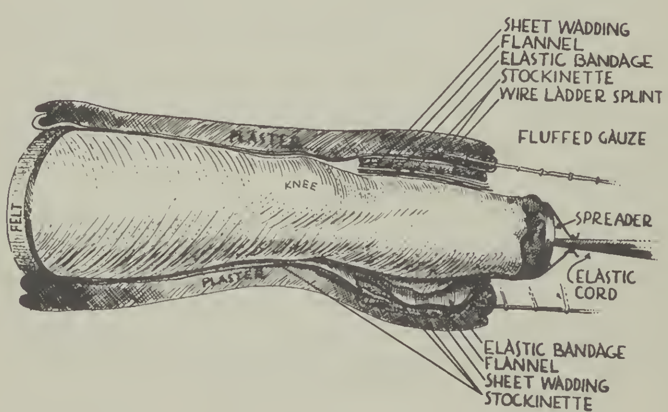

Figure 94 - Diagram of a Traction Cast.

Amputations.

THE TRACTION CAST

It was early recognized that effective traction applied to a lower extremity stump by means of a Thomas splint was invariably uncomfortable and if used for more than a few days would result in a pressure sore over the ischial tuberosity. Padding failed to remedy the situation. Therefore, the traction cast came into general use and has proven satisfactory.

The essential function of a traction cast was to allow an elastic cord or tube to produce adequate traction on the skin of a stump yet distribute the counter traction over such a large portion of the patient's anatomy that pressure sores would be avoided.

One method used for constructing a traction cast was as follows: The portion of the cast about the stump was the same for all amputation sites. The skin was cleansed with ether and "Ace Adherent" painted on with cotton swabs. Sterile stockinette was immediately rolled onto the distal 12 inches of the stump or to the nearest joint, leaving enough hanging over the edge to cover the dressing and allow the fixation of an elastic cord. All wrinkles were smoothed out. Elastic bandage was wrapped snugly but not tightly over the stockinette. If this was used the stockinette never slipped. A single layer of muslin gave the stump dressing a smooth gliding surface. Over this were applied two or three layers of sheet wadding. Then the entire extremity was covered with another layer of stockinette. In the case of the simple cylindrical casts, which were used for amputations distal to the elbow or knee, the stockinette was the only padding used beneath the plaster proximal to the joints, since this was the area where the counter-traction was to be distributed. The elbow was placed at 90° flexion, the knee in full but not forced extension. Generous felt doughnuts were fashioned and taped to the stockinette over bony prominences, such as the head of the fibula. Plaster was applied to within about an inch of the stump end. After several layers of plaster, a wire ladder splint, greased to prevent rusting, was bent into a "U" shape and the open ends incorporated anteriorly and posteriorly into the plaster. A splint placed in this manner supported the weight of the blankets better than one placed laterally.

If the amputation were above the elbow or knee a spica was applied and the stump cuff incorporated into it. Shoulder spicas were more comfortable if extended over the iliac crests to prevent the lower edge digging into the ribs. A mass of sheet wadding was placed in the axilla. During the summer, foot powder was dusted into this sheet wadding to prevent maceration of the axillary skin and keep down fungus growths. Adequate breathing space was obtained by placing a folded

bath towel next to the skin over the anterior chest, then removing it after the plaster was hard. The opposite shoulder of the cast was cut away.

Hip spicas extending only to the iliac crests and liberally cut away in front were adequate and allowed maximum freedom of movement.

The skin of the stump with its attached stockinette would pull down easily in the finished cast due to the sliding motion allowed by the smooth muslin against the sheet wadding.

Pressure sores were avoided because the counter traction was distributed over large areas of soft tissue in the simple cylindrical casts, to the pelvis in general with the hip spica, and to the entire lateral aspect of the chest wall with the shoulder spica.

Postoperative Care.

Even after the administration of 2,000 c.c. of whole blood to a mid-thigh amputation case, for example, the patient would often have a postoperative red cell count of less than 3,400,000. It was felt that the postoperative course was smoother if such a patient were given one or two additional transfusions in the first few days after operation. Efforts at complete restoration of normal blood values were limited by the fear of transfusion complications.

When necessary, secondary dressings were done. Amputations carried out through markedly traumatized tissue could be expected to pour out a profuse serous drainage for two or three days, often saturating the dressing and soiling the bedding. When this had subsided the patient was given a light sodium pentothal anesthesia and the dressing changed. At this time any sloughs or devitalized tissue that had become apparent since the original operation were excised. If the stump appeared clean a traction cast was applied at once. If not, application of the traction cast was delayed and the patient returned to bed. The Thomas splint could not be re-applied because few patients would tolerate it with the necessary traction. Continuous hot wet packs were maintained. Traction was preferably by means of a weight and pulley. Patients were held on average of 4.4 days before evacuation.

In the early part of the war one of the sulfa drugs was routinely given by mouth. In the summer of 1944, penicillin in doses of 20,000 - 25,000 units intramuscularly every three hours starting at admission became routine in all medical installations where surgical teams operated.

Amputations.

TABLE X

Postoperative Complications in Amputation Stumps

	No. Cases
Anaerobic Myositis	16
Abscess	4
Aerobic Cellulitis	2
Devitalized Stump	2
Hemorrhage (Profunda Femoris)	1
TOTAL	25

TABLE XI

Causes of Early Re-amputation

	No. Cases
Anaerobic Myositis	13
Pyogenic Sepsis	1
Devitalized Stump	1
Protrusion of Bone	1
Not Recorded	1
TOTAL	17

Amputations.

TABLE XII

Causes of Death Not Attributable to Other Injuries

	No. Cases
Shock	30
Anaerobic Sepsis	16
Anuria	9
Embolism	4
Fat Embolism	2
Pulmonary Edema	5
Sudden Respiratory Death	1
Cardio-Vascular Accident	1
Tetanus (German POW)	1
Unknown	1
TOTAL	70

The cases of sudden respiratory death and the cardio-vascular accident were probably caused by emboli but were not proven as such.

Pneumonia was remarkable for its absence among the causes of death in a series of 1,028 major amputation cases.

The observed mortality rate for major amputations was 6.81%. Deaths definitely caused by other injuries were not included in this calculation.

TABLE XIII

Mortality in Single Amputations Having no Other Major Injury

Location	No. Cases	No. Deaths	Percent Mortality
Leg	359	2	0.55%
Thigh	278	15	5.39%
Forearm	36	0	
Arm	110	3	2.72%
TOTAL	783	20	2.55%

Amputations.

Those cases having intra-abdominal, intrathoracic, intracranial injuries or compound fractures of long bones were excluded from this calculation.

The 15 deaths in the thigh amputations were from the following causes:

Shock	4
Anaerobic Sepsis	3
Fat Embolism	2
Emboli	1
Blast Injury	1
Pulmonary Edema	1
Anuria	1
Cardio-Vascular Accident	1
Unknown	1
TOTAL	15

One of the deaths in leg amputations was caused by shock and the other by pulmonary edema. The three deaths in arm amputations were caused by tetanus, shock and anaerobic sepsis.

POSTOPERATIVE INFECTIONS IN STUMPS

Early infections in amputation stumps were not common. When they did occur they were most often the result of inadequate debridement, errors in judgment as to the viability of tissue, severance of the blood supply to the remains of a muscle at the time of amputation or inadequate blood replacement therapy. In the amputation of a badly mangled extremity at the lowest possible level the likelihood of errors in judgment as to the viability of tissue increased as the wounding to surgery time decreased, other factors being equal. Performing amputations at any level instead of the sites of election predisposed to the accidental interruption of blood supply to a portion of a muscle group retained in the stump. Instances where this was apt to occur were: (1) an amputation immediately distal to the knee in which the stump of the soleus was deprived of blood supply and (2) a high thigh amputation which deprived the origins of the adductor muscles of blood.

Retained non-viable tissue in a stump invariably led to infection which cleared up when the offending tissue was removed.

Prior to penicillin 13 cases out of 741 amputations developed anaerobic myositis in the stumps postoperatively, an incidence of 1.7%. Of the 13 cases reported, nine occurred in Southern Italy and Sicily.

Amputations. (Postoperative Infections in Stumps, contd).

After the routine administration of penicillin was instituted three cases out of a total of 617 amputations were reported, an incidence of 0.48%. There were only two amputations for anaerobic cellulitis reported. One of these was done before and one after penicillin. The fact that surgical judgment in the management of war amputations improved as time went on cast a cloud over the exact role played by the new drug in the prevention of anaerobic sepsis in stumps.

The occurrence of abdominal distention and hiccoughs was noted several times in high thigh amputations. No cause was ascertained. A Levine tube was used for its relief. In the cases reported it subsided spontaneously.

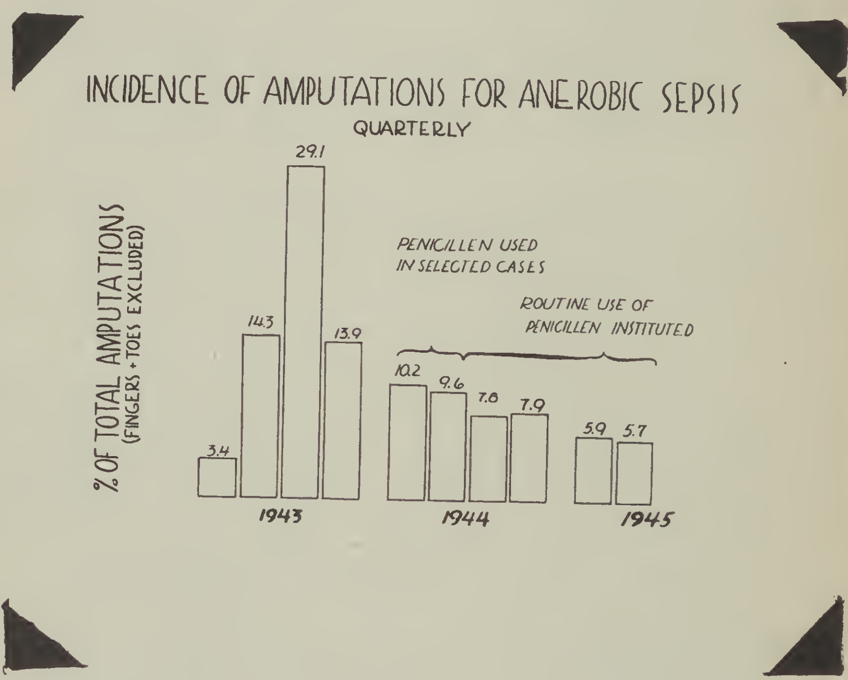

Figure 95 - Quarterly Incidence of Amputations for Anaerobic Sepsis.

Amputations.

AMPUTATIONS SECONDARY TO INFECTIONS

Only one amputation was performed for infection other than clostridial. One hundred and eight amputations were recorded as having been done for anaerobic infection. However, it is interesting to note that all but 11 of these had interruption of the principal blood supply to the infected part. The average time from wounding to initial operation was 28.5 hours. Sixty-seven were amputated at the first operation. Forty-seven were debrided and required later amputation. The average time interval between the two operations was 3.34 days.

It was noted that anaerobic infections resulting in amputation usually had interruption of the principal blood supply to the part. The systemic administration of penicillin could hardly be expected to prevent the development of gas infection when little blood was reaching the site of injury.

AMPUTATIONS SECONDARY TO VASCULAR INSUFFICIENCY

A total of 152 amputations were performed because the extremity was rendered non-viable by vascular injury. Of these, 76 had small wounds only and 76 had severe wounds in addition to the vascular interruption.

The specific arterial injuries resulting in amputations were as follows:

TABLE XIV

Arterial Injuries Resulting in Amputation

	No. Cases
Popliteal	35
Femoral	20
Anterior and Posterior Tibial	9
Axillary	4
Brachial	8
TOTAL	76

Of these 76 cases 46 were amputated at the first operation, the extremity being obviously already dead.

Amputations. (Amputations Secondary to Vascular Insufficiency, contd).

The remaining 30 cases came to operation too early for the appearance of rigor mortis or having a little collateral circulation present. The policy in these was to delay amputation and attempt to restore circulation by removal of thrombi; suture of arterial lacerations, sympathetic blocks, sympathectomy, fasciotomy and transfusions.

It has been repeatedly observed that an extremity which was slowly dying from inadequate blood supply was a potent source of danger. With or without the onset of clinically demonstrable anaerobic infection the patient sometimes began to exhibit symptoms of a profound toxemia. He became listless, or even irrational. The pulse rate would go up to 120/160 and the temperature to 102° - 104°. These symptoms could be relieved at once by amputation. Dissection of the extremity would demonstrate thrombosed vessels, muscles with minimal changes in color and consistency, and often nothing else. The discovery of gas or a pyogenic infection would afford obvious cause for the toxemia.. The onset of anaerobic sepsis in these extremities was common. It occurred even in extremities with no other injury than a small one severing the blood supply. For example, one patient with ligation of the femoral artery proximal to the origin of the profunda femoris had no wounds in the distal third of the thigh, in the calf, or in the foot. Three days after injury the entire calf, including muscles and fascia were spongy with gas.

These observations have served to emphasize the necessity for constant vigil in cases with extremities of questionable viability.

Determination of the viability of an extremity has not always been easy. The blanching test was not accurate. If color returned to an area following pressure with one's thumb it simply meant that blood was present in the extremity. When rigor mortis has been present the extremity has invariably come to amputation even when the circulation has been restored.

The safest rule for selecting the time of amputation has been to await the appearance of a definite rigor mortis. Nothing has been gained by waiting for dry gangrene in battle casualties. Too often severe sepsi has intervened necessitating amputation at a higher level than would have originally been necessary. As has been pointed out, penicillin has prove no safeguard against this tragedy.

The site of amputation selected has been the lowest level at which a viable stump could be obtained. In determination of this level it was deemed necessary that all muscles left in the stump bleed when visible vessels in the muscle belly were cut. Either contractility or normalcy in color and consistency were considered essential. Muscles which appea normal and would bleed but would not contract were considered to be temporarily paralyzed by the blast effect of the injury. They have been left in stumps and have survived.

MANAGEMENT OF AMPUTATIONS IN CONJUNCTION WITH OTHER WOUNDS

Patients having a colostomy and thigh amputation have presented a problem. The traction spica was unsatisfactory because of soiling from the colostomy. Resumption of the use of the Thomas splint was necessary. To avoid pressure sores over the ischial tuberosity the traction was maintained by means of a pulley and a weight hung over the end of the bed until just before evacuation when it was exchanged for an elastic cord fixed to the Thomas splint.

Cases with combinations of an intrathoracic wound and an arm amputation were managed by means of a simple pulley and weight arrangement for traction until ready for evacuation. By this time the daily chest aspirations were no longer necessary and a shoulder spica could be applied. In chest cases particular care was exercised to make the spica roomy. No trouble from interference with respiration was encountered.

The most comfortable shoulder spicas were applied with the patient awake and sitting up. If this was not possible the patient was laid on an ordnance-made canvas strip with ratchet arrangement for drawing it taut. A Thomas arm splint extending over the edge of the table was used when nothing else was available, the patient's head resting in the padded ring. Casts applied by the third method did not fit as well as the others but were satisfactory.

PSYCHOLOGICAL CONDITIONING

Prior to the operation the patient seldom inquired about use of prosthetic appliances and this problem was not discussed with the patient. He was usually too apathetic to worry over such matters. He was often in shock, had had considerable morphine or both. If a dead extremity were in place, the patient was informed of the nature of the impending operation. Often he showed little or no interest in this information. The emotionally unstable patient was especially apt to be heavily narcotized. When he was not, the information was withheld until shortly before the anesthetic so as to lessen the time available for brooding. If a patient displayed enough interest to inquire why an amputation was necessary, the reasons were explained to him and the extremity demonstrated, to his satisfaction, to be already dead.

Regardless of what had been told him preoperatively, the patient was often not aware of the nature of his injury when he recovered from the anesthetic. After being informed of his loss he might ask questions. These were answered definitely - if such was possible - and honestly.

Amputations. (Psychological Conditioning, contd).

High on the priority list of questions was the one as to when he would get back to the United States. This could be answered only by stating that everything possible would be done to speed his return. No estimate of time could be given. The story of a friend or acquaintance with an injury similar to his own was often related - how he was happily married, made a comfortable living, etc. The patient was reminded that the urge to overcome physical disability has often provided the incentive that has resulted in men getting much more out of life than the average. Magazines carrying popular articles about the present status of artificial limbs were helpful, especially since the average soldier's mental picture of an artificial limb was derived from the common peg leg.

SUMMARY

1. The 1131 major amputations performed by surgical teams of the 2nd Auxiliary Surgical Group formed the basis of this report.

2. Most of the cases were done under field conditions, usually in a platoon of a Field Hospital functioning as a first priority surgical hospital.

3. Amputations caused by different agents were sufficiently different in appearance to warrant separate descriptions. Thus, the amputations caused by land mines were characterized by burning of the tissues and stripping of the soft tissues from the bone.

4. Fifty-nine disarticulations were performed. Generally, they were unsatisfactory.

5. The treatment received prior to admission to a surgical installation consisted of pressure dressings, tourniquets, morphine, splints, plasma, and sometimes whole blood. The web cloth tourniquets did not completely control hemorrhage. At the same time, they never caused necrosis.

6. Since shock therapy played such an important role in the early treatment, considerable space was given to this phase. The average admission blood pressure was 81/45. Forty-one patients with amputations and no other major injuries were admitted with no obtainable blood pressure or pulse. All but seven of these survived to be evacuated. This was made possible by an efficient blood bank system.

Amputations. (Summary, contd).

7. The fluctuations of blood pressure that occurred during the early treatment were enumerated. A foreknowledge of these proved to be of great value.

8. The operative technique used was the flapless guillotine amputation. Often this was little more than a debridement of the already existing traumatic amputation. Several points in the mechanics of the operation were mentioned.

9. A detailed description of the traction cast was presented. Minor points in the construction of the cast varied from team to team. For the sake of clarity and brevity only one method of construction was outlined.

10. The mortality was calculated in two different ways. The overall mortality, excluding deaths definitely caused by injuries other than the amputation, was 6.81%. For those cases having a single major amputation and no intracranial, intra-abdominal, intrathoracic injury or compound fracture of a long bone, the mortality rate was 2.55%.

11. Serious postoperative infections in stumps were rare. When they did occur they were almost always the result of dead or foreign material retained in the stump. In view of the fact that the surgeons became more adept in removing these causative factors as time went on, no specific evaluation could be made of the role played by chemotherapy.

12. One hundred and eight amputations were recorded as having been done for anaerobic infection. All but 11 of these had interruption of the principal blood supply to the part.

13. One hundred and fifty-two amputations were done for vascular insufficiency. It was noted that when dealing with battle casualties, a dead or dying extremity was a potent source of danger. The optimum time for amputation was when rigor mortis became definitely demarcated.

14. The psychological aspect of the early treatment of amputation cases was discussed. It was found that many soldiers thought of an artificial limb in terms of the familiar peg leg. By maintaining their confidence, this and other unnecessary apprehensions could be corrected.

COMPOUND FRACTURES

COMPOUND FRACTURES

The following is a report of the study of compound fractures based on the operative records of the surgical teams of the 2nd Auxiliary Surgical Group. The period covered was that between 8 November 1942 and 8 May 1945. The operations, with very few exceptions were performed in first priority hospital installations. The records studied were those of the orthopedic surgical, general surgical and thoracic surgical teams.

All compound fractures were reviewed except those of the ribs, sternum, scapula, patella, skull and face. It was felt that these were adequately covered in the reports of the various specialty teams.

Included in this report are soldiers and civilians whose fractures were incurred in battle or by accidental injury.

A total of 5438 compound fractures were reviewed. Of these 3354 were compound fractures of the long bones and 2084 were of other bones. In this report, the term "long bones" refers to femur, humerus, radius ulna, tibia and fibula only.

It is felt that this study could best be reviewed by presenting it in statistical form and the first section was written with this in mind. In addition there are sections on "Surgical Management"and "Causes of Death".

The 3354 compound fractures of long bones were incurred by 2416 individuals. These fractures are reviewed in detail in this report. All other compound fractures treated by this group were tabulated but the number of individuals which they occurred in were not recorded. It will also be noted that multiple compound fractures of the carpus, metacarpus, tarsus, metatarsus and phalanges were considered in each instance as single fractures of the part. Thus, if four metacarpals were fractured it was considered as a single fracture of the metacarpus.

An uncomplicated compound fracture, in this report, is one without major blood vessel involvement and no other major associated injury. Anaerobic infection, if present on admission, was considered as causing it to be a complicated fracture. A fractured bone with an involvement of an adjacent joint was considered as uncomplicated, the joint injury being part of the fracture process.

If amputation was performed at the initial operation the compound fracture is not included in this series. Cases receiving secondary amputation are included.

Compound Fractures,(cont'd).

PART I STATISTICAL STUDY

TABLE I

Number of Compound Fractures

Long bones	3354
Other bones	2084
TOTAL	5438

TABLE II

Compound Fractures of Long Bones

	No. of Fractures	Percent of all Comp. Fractures	Percent of all Comp. Fractures of Long Bones
Femur	701	12.9%	20.9%
Humerus	590	10.8%	17.6%
Tibia	779	14.3%	23.2%
Fibula	556	10.2%	16.5%
Radius	335	6.2%	9.9%
Ulna	393	7.2%	11.7%
TOTAL	3354	61.6%	99.8%

TABLE III

Compound Fractures of Other Bones

	No. of Fractures	Percent of all Compound Fractures
Spine	284	5.2%
Pelvis	385	7.1%
Clavicle	65	1.2%
Carpus	77	1.4%
Metacarpus	267	4.9%
Phalanges (Hand)	255	4.7%
Tarsus	273	5.0%
Metatarsus	292	5.4%
Phalanges (Foot)	93	1.7%
Patella	93	1.7%
TOTAL	2084	38.3%

Compound Fractures (cont'd).

FEMUR

1. All Compound Fractures

Number of fractures..................................	701
Percent of all compound fractures..................	12.9%
Percent of compound fractures of long bones........	20.9%
Number of patients (Femur only or primary fracture)	668
Number of deaths..................................	61
Percent mortality..................................	9.1%

2. Uncomplicated Fractures

Number of fractures..................................	401
Percent of all compound fractures of femur.........	57.4%
Percent of compound fractures of long bones........	11.9%
Number of patients..................................	401
Number of deaths..................................	4
Percent mortality..................................	1.0%

3. Complicated Fractures

Number of fractures..................................	300
Percent of all compound fractures of femur.........	42.7%
Percent of all compound fractures of long bones....	8.2%
Number of patients (Femur only or primary fracture)	267
Number of deaths..................................	57
Percent mortality..................................	21.3%

4. Statistics on all Compound Fractures of Femurs

a. Fracture site

Fracture site	Number of each
Upper third	183
Middle third	114
Lower third	282
Not recorded	122

b. Bilateral fractures - 14 patients.

c. Fractures of femur associated with other more severe fractures - 19.

d. Joint involvement.

Knee in 139 fractures.
Hip in 17 fractures.

Compound Fractures, (Femur, cont'd).

e. Associated with fractures of other long bones.

Tibia	42 Fractures
Fibula	11 Fractures
Tibia and Fibula	38 Fractures
Humerus	30 Fractures
Radius and/or ulna	31 Fractures

f. Associated with vascular injury*.

Femoral artery (Part not stated)	20 Fractures
Femoral vein	20 Fractures
Popliteal artery	15 Fractures
Popliteal vein	15 Fractures
Profunda femoris artery	11 Fractures
Profunda femoris vein	2 Fractures

g. Associated with Nerve Injuries.

Sciatic nerve	20 Fractures
Peroneal nerve	11 Fractures
Tibial nerve	2 Fractures

h. Associated with other Injuries.

Penetrating wound of abdomen	102 Fractures
Penetrating wound of chest	41 Fractures
Thoraco-abdominal wound	18 Fractures
Traumatic amputation	37 Fractures

i. Complications**.

Anaerobic infection present on admission	12 Fractures
Anaerobic infection developed after admission	16 Fractures
Gangrene due to avascularity	6 Fractures

j. Anesthetic agents used.

	No. of Patients
Ether	338
Pentothal	97
Gas-oxygen-ether	198
Pentothal-ether	5
Spinal	21
Local	2
No record	7
TOTAL	668

*Refer to Section on vascular injuries, page 715 to 745
**Refer to section on "Anaerobic Infections", page 746 to 757

Compound Fractures, (Femur, cont'd).

k. Deaths.

	No. of Patients
Shock	17
Pulmonary embolism	9
Anaerobic infection	8
Anuria	6
Peritonitis	2
Pulmonary edema	2
Pneumonia	1
Blast-lung	1
Aspiration asphyxia	1
TOTAL	61

5. Statistics on Uncomplicated Compound Fractures of Femur.

a. Fracture site

Fracture site	No. of Patients
Upper third	100
Middle third	87
Lower third	142
Unclassified	72
TOTAL	401

b. Time Lag.

	No. of Patients
0-8 hours	103
8-16 hours	100
16-24 hours	53
Over 24 hours	81
Not stated	64
TOTAL	401

c. Shock.

	No. of Patients
Systolic blood pressure over 100 mm.	135
Systolic blood pressure 71-100 mm.	74
Systolic blood pressure 41-70 mm.	17
Systolic blood pressure 0-40 mm.	5
Unclassified	170
TOTAL	401

Compound Fractures, (Femur, cont'd).

d. Resuscitation.

	No. of Patients
Received treatment	205
No treatment necessary	60
No treatment recorded	136
TOTAL	401

e. Anesthetic agents used.

	No. of Patients
Ether	192
Pentothal	100
Gas-oxygen-ether	75
Pentothal-ether	2
Spinal	28
Not recorded	4
TOTAL	401

f. Anaerobic infection.

	No. of Patients
Developed after admission	2

(Amputation not necessary; both survived.)

g.

	No. of Patients
Deaths*	4
Shock	3
Pulmonary embolism	1

HUMERUS

1. All Compound Fractures.

Number of fractures	590
Percent of all compound fractures	10.8%
Percent of compound fractures of long bones	17.5%
Number of patients (Humerus only or primary fracture)	545
Number of deaths	37
Percent mortality	6.8%

*See page 649

Compound Fractures, (Humerus, cont'd).

2. Uncomplicated Fractures.

Number of fractures	281
Percent of all compound fractures of humerus	47.6%
Percent of compound fractures of long bones	8.4%
Number of patients	281
Number of deaths	0
Percent mortality	0

3. Complicated Fractures.

Number of fractures	309
Percent of all compound fractures of humerus	52.4%
Percent of compound fractures of long bones	9.1%
Number of patients (Humerus only or primary fracture)	264
Number of deaths	37
Percent mortality	14.0%

4. Statistics of all Compound Fractures of Humerus.

a.

Fracture Site	No. of Each
Upper third	185
Middle third	83
Lower third	204
Not recorded	118

b.

	No. of Patients
Bilateral fractures	8

c.

	No. of Patients
Fractures of humerus associated with other more severe fractures	37

d. Joint involvement.

Elbow in 88 fractures.
Shoulder in 51 fractures.

e. Associated with fractures of other long bones.

Radius 25 fractures.
Ulna 31 fractures.
Radius and ulna 42 fractures
Femur 30 fractures.

Compound Fractures, (Humerus, cont'd).

f. Associated with vascular injury.

Brachial artery........................	29 Fractures.
Brachial vein..........................	3 Fractures.
Axillary artery........................	3 Fractures.
Radial artery..........................	4 Fractures.
Anterior humeral circumflex artery.....	3 Fractures.

g. Associated with nerve injury.

Radial nerve...........................	73 Fractures.
Ulnar nerve............................	48 Fractures.
Median nerve...........................	25 Fractures.
Brachial plexus	3 Fractures.

h. Associated with other injuries.

Penetrating wound of abdomen...........	66 Fractures.
Penetrating wound of chest.............	54 Fractures.
Thoraco-abdominal wound................	25 Fractures.
Traumatic amputation...................	10 Fractures.

i. Complications*.

Anaerobic infection developed after admission..........................	8 Fractures.
Gangrene due to avascularity...........	7 Fractures.

j. Anesthetic agent used.

	No. of Patients.
Ether..................................	187
Pentothal..............................	201
Gas-oxygen-ether.......................	138
Pentothal-ether........................	7
Local..................................	7
Not recorded...........................	5
TOTAL..............................	545

*Refer to Section on "Anaerobic Infections", page 746 to 757

Compound Fractures, (Humerus, cont'd).

k. Deaths.

	No. of Patients
Shock	16
Anuria	3
Anaerobic infection	3
Peritonitis	3
Pneumonia	3
Pulmonary embolism	3
Brain damage	3
Blast-lung	1
Pulmonary edema	1
Aspiration asphyxia	1
TOTAL	37

5. Statistics on Uncomplicated Fractures of Humerus.

a. Fracture site

Fracture site	No. of Patients
Upper third	105
Middle third	41
Lower third	89
Unclassified	46
TOTAL	281

b. Time lag.

	No. of Patients
0-8 hours	75
8-16 hours	97
16-24 hours	41
Over 24 hours	42
Not stated	30
TOTAL	281

c. Shock.

	No. of Patients
Systolic blood presure over 100 mm	134
Systolic blood pressure 71 to 100 mm	18
Systolic blood pressure 41 to 70 mm	6
Systolic blood pressure 0 to 40 mm	0
Unclassified	123
TOTAL	281

Compound Fractures, (Humerus, cont'd).

d. Resuscitation.

	No. of Patients
Received treatment	86
No treatment necessary	85
No treatment recorded	110
TOTAL	281

e. Anesthetic agents used.

	No. of Patients
Ether	92
Pentotnal	148
Gas-oxygen-ether	29
Pentothal-ether	5
Local	4
Not recorded	3
TOTAL	281

f.

	No. of Patients
Anaerobic infection developed after admission	1

g. Deaths - None.

RADIUS

1. All Compound Fractures (Except those in combination of radius and ulna).

Number of fractures	173
Percent of all compound fractures	3.2%
Percent of compound fractures of long bones	5.2%
Number of patients (radius only or primary fracture)	142
Number of deaths	6
Percent mortality	4.2%

2. Uncomplicated Fractures.

Number of fractures	78
Percent of all compound fractures of radius	45.1%
Percent of compound fractures of long bones	2.3%
Number of patients	78
Number of deaths	0
Percent mortality	0

Compound Fractures, (Radius, cont'd).

3. Complicated Fractures.

Number of fractures..........................	95
Percent of all compound fractures of radius...	54.9%
Percent of compound fractures of long bones...	2.8%
Number of patients (radius only or primary fracture)................................	64
Number of deaths.............................	6
Percent mortality............................	9.4%

4. Statistics on all Compound Fractures of Radius.

a. Bilateral fractures (radius alone on each side)................................. None.

b. Fractures of radius associated with other more severe fractures.................. 31

c. Joint involvement.

Elbow in 10 fractures.
Wrist in 8 fractures.

d. Associated with vascular injury.

Radial vessels, 9 fractures.
Ulnar vessels, 4 fractures.

e. Associated with nerve injury.

Median nerve, 8 fractures.
Ulnar nerve, 4 fractures.
Other nerves, 10 fractures.

f.

	No. of Patients.
Anaerobic Infection..................	1

Compound Fractures, (cont'd).

ULNA

1. All Compound Fractures of Ulna (except those in combination of radius and ulna).

Number of fractures........................... 231
Percent of all compound fractures............. 4.2%
Percent of compound fractures of long bones.. 6.9%
Number of patients (ulna only or primary fracture).................................183
Number of deaths.............................. 6
Percent mortality............................. 3.3%

2. Uncomplicated Fractures.

Number of fractures...........................107
Percent of all compound fractures of ulna.... 46.3%
Percent of compound fractures of long bones.. 3.1%
Number of patients............................107
Number of deaths.............................. 0
Percent mortality............................. 0

3. Complicated Fractures.

Number of fractures...........................124
Percent of all compound fractures of ulna.... 53.7%
Percent of compound fractures of long bones.. 3.6%
Number of patients (Ulna only or primary fracture)................................ 76
Number of deaths.............................. 6
Percent mortality............................. 7.9%

4. Statistics on all Compound Fractures of Ulna.

a. Bilateral fractures (ulna alone on each side)................................. None

b. Fractures of ulna associated with other more severe fractures................. 58

c. Joint involvement.

Elbow in 60 fractures.
Wrist in 3 fractures.

d. Associated with vascular injury.

Radial vessels, 1 fracture.
Ulnar vessels, 9 fractures.

Compound Fractures, (Ulna, cont'd).

e. Associated with nerve injury.

Ulnar nerve.........................	23 Fractures.
Median nerve........................	8 Fractures.
Other nerves........................	2 Fractures.

RADIUS AND ULNA

1. All Compound Fractures (Combined radius and ulna).

Number of combined fractures..............	162
Number of bones fractured.................	324
Percent of all compound fractures.........	5.8%
Percent of compound fractures of long bones..................................	4.8%
Number of patients (radius and ulna only or primary fracture)..................	103
Number of deaths..........................	7
Percent mortality.........................	6.8%

2. Uncomplicated Combined Fractures.

Number of combined fractures..............	58
Percent of all combined compound fractures of radius and ulna...............	35.8%
Number of bones fractured.................	116
Percent of compound fractures of long bones..................................	3.4%
Number of patients........................	58
Number of deaths..........................	0
Percent mortality.........................	0

3. Complicated Combined Fractures.

Numbers of combined fractures.............	164
Percent of all combined compound fractures of radius and ulna...............	64.2%
Number of bones fractured.................	208
Percent of compound fractures of long bones..................................	6.2%
Number of patients (radius and ulna only or primary fracture)..................	45
Number of deaths..........................	7
Percent mortality.........................	15.5%

Compound Fractures, (Radius and Ulna, cont'd).

4. Statistics on all Combined Compound Fractures of the Radius and Ulna.

a. Bilateral fractures (radius and ulna on each side).............................. None.

b. Combined fractures of radius and ulna associated with other more severe fractures.............................. 59

c. Joint involvement.

Elbow in 30 fractures.
Wrist in 7 fractures.

d. Associated with vascular injury.

Radial vessles......................... 8 Fractures.
Ulnar vessels.......................... 5 Fractures.

e. Associated with nerve injury.

Ulnar nerve............................14 Fractures.
Median nerve...........................15 Fractures.
Other nerves........................... 5 Fractures.

TIBIA

1. All Compound Fractures (Except those in combinations of tibia and fibula).

Number of fractures......................393
Percent of all compound fractures......... 7.2%
Percent of compound fractures of long bones.................................11.4%
Number of patients (tibia only or primary fracture).........................309
Number of deaths......................... 10
Percent mortality........................ 3.2%

Compound Fractures, (Tibia, cont'd).

2. Uncomplicated Fractures.

Number of fractures	193
Percent of all compound fractures of tibia	47.7%
Percent of compound fractures of long bones	5.7%
Number of patients	193
Number of deaths	0
Percent mortality	0

3. Complicated Fractures.

Number of fractures	200
Percent of all compound fractures of tibia	52.3%
Percent of compound fractures of long bones	5.9%
Number of patients (tibia only or primary fracture)	116
Number of deaths	10
Percent mortality	8.6%

4. Statistics on all Compound Fractures of Tibia.

a. Bilateral fractures (tibia only on each side)	6
b. Fracture of tibia associated with other more severe fractures	78

5. Statistics on Uncomplicated Compound Fractures of the Tibia.

a. Time Lag	No. of Patients
0-8 hours	57
8-16 hours	59
16-24 hours	29
Over 24 hours	26
Not stated	22
TOTAL	193

b. Shock	No. of Patients
Systolic blood pressure over 100 mm.	92
Systolic blood pressure 71-100 mm.	4
Systolic blood pressure 41-70 mm.	4
Systolic blood pressure 0-40 mm.	0
Unclassified	93
TOTAL	193

Compound Fractures, Tibia, cont'd).

c. Resuscitation.

	No. of Patients
Received treatment	46
No treatment necessary	61
No treatment recorded	86
TOTAL	193

d. Anesthetic agents used.

	No. of Patients
Ether	47
Pentothal	115
Gas-oxygen-ether	12
Pentothal-ether	3
Endotracheal	2
Spinal	10
Local	3
Not recorded	1
TOTAL	193

e. Joint involvement.

Knee in 14 patients.
Ankle in 8 patients.

f. Anaerobic infection developed after admission 1 patient

g. Deaths...None

FIBULA

1. <u>All Compound Fractures (except those in combinations of tibia and fibula).</u>

Number of patients	170
Percent of all compound fractures	3.1%
Percent of all compound fractures of long bones	5.1%
Number of patients (fubula only or primary fracture)	137
Number of deaths	4
Percent mortality	2.9%

Compound Fractures, (Fibula, cont'd).

2. Uncomplicated Fractures.

Number of fractures..........................	78
Percent of all compound fractures of fibula..	46.0%
Percent of compound fractures of long bones..	2.3%
Number of patients...........................	78
Number of deaths.............................	0
Percent mortality............................	0

3. Complicated Fractures.

Number of fractures..........................	92
Percent of all compound fractures of fibula..	54.0%
Percent of compound fractures of long bones..	2.4%
Number of patients (fibula only or primary fracture)................................	59
Number of deaths.............................	4
Percent mortality............................	6.8%

4. Statistics on all Compound Fractures of Fibula.

a. Bilateral fractures (fibula only on each side)................................	4
b. Fracture of fibula associated with other more severe fractures...........	29

5. Statistics on Uncomplicated Compound Fractures of the Fibula.

a. Time Lag.

	No. of Patients
0-8 hours..............................	23
8-16 hours.............................	24
16-24 hours............................	9
Over 24 hours..........................	15
Not stated.............................	7
TOTAL..............................	78

b. Shook.

	No. of Patients
Systolic blood pressure over 100 mm......	31
Systolic blood pressure 71-100 mm...	5
Systolic blood pressure 41-70 mm....	2
Systolic blood pressure 0-40 mm.....	1
Unclassified............................	39

Compound Fractures, (Fibula, cont'd).

c. Resuscitation.

	No. of Patients
Received treatment	21
No treatment necessary	24
No treatment recorded	33
TOTAL	78

d. Anesthetic agents used.

	No. of Patients
Ether	17
Pentothal	54
Gas-oxygen-ether	3
Pentothal-ether	1
Spinal	1
Local	2
TOTAL	78

e. Joint involvement.

Knee in 1 patient.
Ankle in 5 Patients.

f. Anaerobic infection.................... None.

g. Deaths................................. None.

TIBIA AND FIBULA

1. All Compound Fractures (Combined tibia and fibula).

Number of combined fractures	386
Number of bones fractured	772
Percent of all compound fractures	14.0%
Percent of compound fractures of long bones	11.5%
Number of patients (Tibia and fibula only or primary fracture)	329
Number of deaths	21
Percent mortality	6.4%

Compound Fractures, (Tibia and Fibula, cont'd).

2. Uncomplicated Combined Fractures.

Number of combined fractures..................	154
Percent of all combined compound fractures of tibia and fibula..........................	40.2%
Number of bones fractured.....................	308
Percent of compound fractures of long bones...	9.2%
Number of patients............................	154
Number of deaths..............................	0
Percent mortality.............................	0

3. Complicated Compound Fractures.

Number of combined fractures..................	232
Percent of all combined compound fractures of tibia and fibula..........................	59.8%
Number of bones fractured.....................	464
Percent of compound fractures of long bones...	13.6%
Number of patients (tibia and fibula only or primary fracture)..........................	175
Number of deaths..............................	21
Percent mortality.............................	12.0%

4. Statistics on all Combined Compound Fractures of Tibia and Fibula.

a. Bilateral fractures (tibia and fibula on each side)..............................	19
b. Combined fractures of tibia and fibula assocated with other more severe fractures..............................	38

5. Statistics on Uncomplicated Combined Fractures of Tibia and Fibula.

a. Time Lag.

	No. of Patients
0-8 hours..................................	57
8-16 hours.................................	33
16-24 hours................................	14
Over 24 hours..............................	21
Not stated.................................	29
TOTAL..................................	154

Compound Fractures, (Tibia and Fibula, cont'd).

b. Shock.

	No. of Patients
Systolic blood pressure over 100 mm.....	67
Systolic blood pressure 71-100 mm..	14
Systolic blood pressure 41-70 mm...	2
Systolic blood pressure 0-40 mm....	4
Unclassified...........................	67
TOTAL..................................	154

c. Resuscitation.

	No. of Patients
Received treatment......................	57
No treatment necessary..................	46
No treatment recorded...................	51
TOTAL..................................	154

d. Anesthetic agents used.

	No. of Patients
Ether..................................	60
Pentothal..............................	64
Gas-oxygen-ether.......................	18
Pentothal-ether........................	2
Endotracheal...........................	2
Spinal.................................	6
Local..................................	2
TOTAL..................................	154

e. Joint involvement.

Knee in 4 patients.
Ankle in 9 patients.

f. Anaerobic infection developed after admission - None.

g. Deaths - None.

TABLE IV

All Compound Fractures of Long Bones

Bone	No. of Compound Fractures	Percentage of all Compound Fractures	Percentage of all Compound Fractures of Long Bones	No. of Patients	Deaths	Percentage of mortality
Femur	701	12.9%	20.9%	668	61	9.1%
Tibia	393	7.2%	11.4%	309	10	3.2%
Fibula	170	3.1%	5.1%	137	4	2.9%
Combined Tibia and fibula	772 fractures (386 comb.)	14.0%	23.0%	329	21	6.4%
Humerus	590	10.8%	17.6%	545	37	6.8%
Radius	173	3.2%	5.2%	142	6	4.2%
Ulna	231	4.2%	6.9%	183	6	3.3%
Combined radius and ulna	324 fractures (162 comb.)	5.8%	9.6%	103	7	6.8%
TOTAL	3354		99.7%	2416	152	6.3%

Compound Fractures, (cont'd).

TABLE V

Uncomplicated Compound Fractures of Long Bones

Bone	No. of Uncomplicated Compound Fractures	Percentage of all Compound Fractures of Specific Bones	Percentage of all Compound Fractures of Long Bones	No. of Patients	Deaths	Percentage of Mortality
Femur	401	57.4%	11.9%	401	4	1.0%
Tibia	193	47.7%	5.7%	193	0	0%
Fibula	78	46.0%	2.3%	78	0	0%
Combined tibia and fibula	308 fractures (154 combined)	40.2%	18.4%	154	0	0%
Humerus	281	47.6%	8.4%	281	0	0%
Radius	78	45.1%	2.3%	78	0	0%
Ulna	107	46.3%	3.1%	107	0	0%
Combined radius and ulna	116 fractures (58 combined)	35.8%	6.8%	58	0	0%
TOTAL	1562		58.9%	1350	4	0.3%

TABLE VI

Complicated Compound Fractures of Long Bones

Bone	No. of Complicated Compound Fractures	Percentage of all Compound Fractures of Specific Bone	Percentage of all Compound Fractures of Long Bones	No. of Patients	Deaths	Percentage of Mortality
Femur	300	42.7%	8.2%	267	57	21.3%
Tibia	200	52.3%	5.9%	116	10	8.6%
Fibula	92	54.0%	2.4%	59	4	6.8%
Combined tibia and fibula	464 fractures (232 combined)	59.8%	27.2%	175	21	12.0%
Humerus	309	52.4%	9.1%	264	37	14.0%
Radius	95	54.9%	2.8%	64	6	9.4%
Ulna	124	53.7%	3.6%	76	6	7.9%
Combined radius and ulna	208 fractures (104 combined)	64.2%	12.4%	45	7	15.5%
TOTAL	1792		71.6%	1066	148	13.9%

COMPOUND FRACTURES
PART II

SURGICAL MANAGEMENT OF COMPOUND FRACTURES

Patients with compound fractures, the results of battle and accidental wounds, represent long term problems in treatment to the Army Medical Department. This is particularly true of fractures of the major long bones. The management of these patients is spread over all echelons and zones and the care of each patient is divided among numerous hospitals and is carried out by many different medical officers. To obviate, in so far as possible, the dangers inherent in such a situation the treatment of these patients has been divided into four periods each of which is carefully limited in scope and purpose. These periods are: 1) First-aid splinting in the field and subsequent care through the various divisional medical installations. 2) Surgical debridement and transportation splinting in a mobile hospital (Field or Evacuation). 3) Final correction of deformity and attainment of wound healing in a fixed hospital. 4) Reconstructive surgery in hospitals of the Zone of Interior.

All but a few of the patients handled by teams of this Group were in Evacuation or Field Hospitals. Therefore this report deals only with patients in the second phase of their treatment when they are receiving their initial surgery and being prepared for evacuation to a fixed hospital.

Initial surgery and handling of these patients became highly standardized as experience was gained. With a few exceptions the surgeons of this Group adhered closely to a course of procedure outlined by the Theater Surgeon. This procedure was altered from time to time to include new developments and the lessons learned from increased experiences. The fundamental surgical principles remained unchanged, however.

Most patients when received at mobile hospitals were well splinted and had received plasma as indicated. Many patients were ready for surgery without additional preoperative treatment. Others had additional and more serious concomitant wounds and required special attention depending upon the nature of their other wounds. Still others were in verying degrees of shock from the fracture wounds. Some of these had multiple fractures, most had severe wounds, and many had associated vascular injury with hemorrhage. In these the shock from whatever cause had to be treated before surgery could be started.

PREOPERATIVE CARE

Patients received tetanus toxoid routinely, usually before reaching the hospital. Upon admission and every three hours thereafter all patients received 20,000 to 25,000 units of penicillin (this latter routine was begun in June 1944).

Part II, Compound Fractures, (Preoperative Care, cont'd).

During the first examination, splints were inspected for possible embarrassment to circulation and tourniquets were removed or loosened while keeping the patient under close observation. In most cases the problem of tourniquets had been handled well.

Resuscitation consisted of the liberal use of plasma, whole blood and crystalloid solutions. In most instances patients were quickly stabilized, especially if the shock was primarily due to hemorrhage and this was controlled. There was one group of patients which was found to be difficult or impossible to stabilize adequately. These patients usually had severe and extensive damage to bone and soft tissue of the thigh or leg. In spite of large amounts of blood and plasma it was often impossible to obtain a pulse rate under 140 per minute or to raise the blood pressure to 100 mm. Hg. In others shock would rapidly recur if therapy were not continued vigorously. As experience was gained it was learned that in these types of cases early surgery with continued active shock treatment was imperative and that as soon as operation was completed the patient improved rapidly. Thereafter, these patients were given high priority.

Roentgen-ray examination is essential and was carried out in almost all cases. Whenever possible the more severely wounded patients were roentgen-rayed on their way to surgery in order to obviate additional moving. Aside from visualization of the fracture, roentgen-ray examination is necessary for the localization of opaque foreign bodies and there should always be two different views of the part in question. Fluoroscopy was used occasionally in rush periods.

OPERATIVE PROCEDURES

As much of the preparation of the operative area as possible was done before the induction of anesthesia. That which required painful movement was delayed until after induction. It was customary to shave a large area of the affected part and to include the entire circumference. The skin was washed with white soap and water. The wound itself was not prepared except to remove gross dirt and foreign materials at times or to flush obviously dirty wounds with saline or water. Most surgeons used an antiseptic solution on the surrounding skin before draping.

Actual surgery began with enlargement of the wounds by incision in the long axis of the part. Very few of the original wounds were large enough without additional incision. The incision was continued through fascia and this layer was often split far up and down under intact skin. As experience increased the incisions of the wounds became larger. At first skin wounds were circumcised but later only devitalized skin was excised. All devitalized tissue, particularly muscle, was excised to normal areas. This was done even if it required

removal of an entire muscle or group of muscles. A serious attempt was made to find and remove all foreign materials. Counterincisions were used frequently for the removal of foreign bodies. Loose bone fragments were removed. Counterincisions were also used to obtain dependent drainage in all areas where it was necessary. This latter procedure is necessary in almost all thigh and calf wounds with fractures in which the original wounds are anteriorly placed. In femur fractures stress was placed upon postero-lateral drainage proximal to the fractures, and incisions were made through the fibrous attachments to the linea aspera of the femur. Many surgeons flushed fracture wounds with sterile water or saline to remove additonal dirt and loose tissue fragments after surgery was completed. This was not always possible.

Sulphanilamide was dusted into all wounds prior to the routine use of penicillin intramuscularly. After the advent of penicillin most surgeons continued to use local sulphanilamide but others discontinued it entirely. There were no obvious differences in the wounds treated by the two methods.

At first all wounds had strips of vaseline gauze placed into their depths. In many cases this amounted to packing which was not desired. Later, either vaseline gauze or plain fine mesh gauze was used to separate the skin and fascial edges.

Immobilization was almost invariably attained by plaster splints or casts. It must be remembered that the splinting was for transportaion only. It was not intended for anatomic reduction or fixation for a prolonged time. It was this limitation of scope and purpose which made standardization possible and the use of plaster casts routine. In addition to the ordinary principle in the use of plaster casts there are two which were found to be essential in war surgery. They are: 1) Adequate padding of all casts, and, 2), splitting or bivalving of all casts through all layers to the skin. Very few exceptions were made to these requirements in this series of cases. Special types of casts will be discussed below.

<u>Femur.</u>

The most popular cast for fractures of the femur was the "one and one-half" plaster spica with a low waist which did not encroach upon the costal cage. It extended to just above the knee on the good side. The knee on the affected side was slightly flexed and the thighs placed in only slight abduction. Greater abduction interfered with handling during transportation.

A variation of this method used by some surgeons was the single plaster spica extending well up onto the costal cage to obtain immobilization. The objections to this cast are the restricted waist motion and discomfort over the lower ribs.

Part II, Compound Fractures, (Operative Procedures, contd).

The Tobruk cast waw used very infrequently and when used was limited almost entirely to lower third fractures of the femur and injuries to the knee joint. A few were applied when it was essential to keep the abdomen and lower back exposed for subsequent surgery or treatment.

Humerus.

Here again there was a popular cast. This was the plaster Velpeau bandage which bound the arm to the trunk with the forearm flexed to a right angle and placed across the chest. Since there was no circular bandage around the arm it was unnecessary to split the cast in most instances. The casts were usually comfortable and were not made heavy. It could be applied by pulling the patient out over the head of the table and supporting him on a narrow board, broom handle or Jones arm splint placed under the spine and head. This temporary appliance was removed after the plaster had set.

A satisfactory variation of this method but less popular in this Group was the thoraco-brachial cast (including long slab splints) with the arm forward in internal rotation and the forearm at a right angle.

The Army humerus splint was used temporarily in some cases with concomitant chest injuries and in patients too ill to place in a cast at the time of the original operation.

Radius and Ulna.

Fractures of the forearm were almost all treated by circular plaster bandage (with slab splint), with right angle flexion of the elbow and with the cast extending from the proximal palmar crease to just below the axillary folds. The hand was usually kept midway between pronation and supination.

Tibia and Fibula.

Here a circular plaster bandage (with posterior slab spint) was used. It extended from the toes to the groin with the knee slightly flexed and foot in neutral position. The posterior slab splint was extended distally beyond the toes for support and protection.

SPECIAL CONSIDERATIONS IN SURGERY

Amputation.*

As nearly as can be determined no amputation was done for a fracture alone. Amputations were done for non-viability or irreparable damage which would leave a functionless extremity. In some cases, however, the presence of a severely comminuted fracture was the deciding factor in an otherwise questionable situation.

*Refer to Section on "Amputations", Page 593 to 619

Associated Injury to a Major Vessel.**

The treatment was the same except that special attention was paid to the preservation of all possible collateral circulation and the casts were more heavily padded.

Old Fractures.

Untreated fractures of 48 hours or longer duration received the same treatment except that in the presence of infection larger doses of penicillin and larger amounts of blood were given prior to surgery to improve the general condition.

Anaerobic Infection.***

The presence of a fracture does not fundamentally alter the treatment of anaerobic infection. Incision, debridement, or amputation was done as indicated by the severity of the infection and not because of the presence of a fracture. When amputation was done the fracture line was often used as the level of amputation even though the infection may have extended higher.

POSTOPERATIVE CARE

Penicillin was continued postoperatively in 20,000 - 25,000 unit doses every three hours, usually until evacuation. In cases of actual or suspected anaerobic infection this was doubled. Intravenous fluids, crystalloids, plasma, and whole blood were used freely and as indicated to maintain as nearly as possible a normal physiologic status. Full diet was given as soon as it could be tolerated. Some surgeons gave vitamins routinely.

It is essential that all casts be watched carefully and constantly. It was found that frequent adjustments, trimmings and paddings were necessary for the comfort of the patient.

EVACUATION

Early evacuation to a fixed hospital was the general policy with fracture patients. Many patients were evacuated on the day following operation and most within three or four days. Associated chest or abdominal injuries, cases with anaerobic infection and all patients with associated major vascular injury had to be retained longer. Air evacuation is ideal and was used for many of these patients.

**Refer to Section on "Vascular Injuries", page 715 to 745
*** Refer to Section on "Anaerobic Infections", page 746 to 757

Compound Fractures, (cont'd).

PART III

MORTALITY IN PATIENTS WITH COMPOUND FRACTURES OF LONG BONES

In considering mortality among patients suffering from compound fractures of long bones it immediately becomes apparent that we must divide our cases into complicated and uncomplicated groups. The entire series of cases under consideration at present represent soldiers and occasionally civilians whose injuries have occurred under war conditions highly favorable to multiple serious wounds of all parts of the body simultaneously. By complicated therefore it follows that it will be understood that the injuries in combination with a compound fracture constitute as much if not more of a threat to survival than the fracture itself. These combined injuries include penetrating chest and abdominal wounds, associated fractures of other long bones, major vascular injuries accompanying the primary fracture or in association with other wounds, extensive soft tissue damage in addition to that incident to the fracture, central nervous system trauma, maxillo-facial trauma and traumatic amputations. Uncomplicated compound fractures constitute a very small group in this mortality series.

In this series 2416 patients were found to have suffered from compound fractures of the long bones. Of these 1066 were complicated, and 1350 were uncomplicated. Further analysis reveals a total of 152 deaths occuring in this series of 2416 cases making a gross mortality rate of 6.3%. Of these 152 deaths, 145 fell in the complicated compound fracture group making a mortality rate of 13.9%. The remaining four deaths fell in the uncomplicated group making a mortality rate of .3%. Interestingly enough all four of the deaths in this uncomplicated group were due to compound femurs.

TABLE VII

Mortality Percentage

	No. of Patients	Deaths	Percent
All compound fractures	2416	152	6.3%
Complicated compound fractures	1066	148	13.9%
Uncomplicated compound fractures	1350	4	.3%

Further analysis of the mortality statistics of the compound fractures with associated major injuries of the body would seem helpful in understanding the extent and degree of associated injuries with the various long bone fractures. For this purpose the following table is included.

Part III, Compound Fractures (Mortality in Patients With Compound Fractures of Long Bones, cont'd).

TABLE VIII

Incidence of Associated Injuries in Fatal Cases of Complicated Compound Fractures of Long Bones

Associated Injuries	Femur 57 pts.	Tibia 31 pts.	Fibula 4 pts.	Humerus 37 pts.	Radius 13 pts.	Ulna 6 pts.
Abdominal	27	20	2	17	8	3
Chest	8	5	0	7	2	0
Thoraco-abdominal	3	1	1	6	3	1
Compound Fractures other large bones	25	32	0	11	7	1
Traumatic amputations	8	4	0	0	2	2
Vascular injuries (major)	10	4	2	5	3	0
Multiple soft tissue wounds	8	5	0	4	0	1

Having seen in the foregoing table the actual numerical relation of other major injuries with compound fractures of long bones, we shall proceed to a direct review of the causes of death in an effort to understand more clearly the part played by the fracture and the part played by the associated injury. It is our feeling that a great number of the complicated compound fractures are so overshadowed by the associated injury in the production of a fatal result that the fracture per se can reasonably be said to have been of relatively minor importance. In many instances death occurred on the table during thoracic or abdominal exploration before any definitive treatment could be directed toward the fracture. Again there are a few instances where sudden death was attributed to aspiration of vomitus postoperatively or, as in one case, sensitivity to morphine injected intravenously during the postoperative period. Again too, it is unfortunate that the ascribable cause of death is not uniformly based upon postmortem anatomical diagnosis, but on more debatable clinical grounds. Still further when autopsy reports were available the description of microscopic change was lacking, making at best a gross diagnosis the only one available. The following table lists the various causes of death occurring in all cases of fractures of the long bones.

Part III, Compound Fractures (Mortality in Patients With Compound Fractures of Long Bones, cont'd).

TABLE IX

Immediate Causes of Death, 152 Cases of Compound Fractures of Long Bones

Cause of Death	Femur	Tibia	Fibula	Humerus	Radius	Ulna	Total
Not stated	14	2		1	1	2	20
Shock	17	15	1	16	5	1	55
Anaerobic infection	8	3		3		1	15
Peritonitis	2	3		3	1		9
Anuria	6	2	2	3	3	1	7
Pneumonia	1	1		3	1		6
Embolism	9	1		3	1	1	15
Blast injury lung	1	1		1			3
Pulmonary edema	2	2		2			6
Asphyxia, aspiration	1	1		1			3
Cerebral damage			1	1			2
Morphine sensitivity					1		1
TOTAL	61	31	4	37	13	6	152

In considering the foregoing table it will be noted that the first cause of death, namely, not stated or unknown, includes a rather large number of cases. In all of these, careful scrutiny of the records failed to give enough data even for clinical speculation as to cause of death. Shock as a cause of death covers the largest group of cases and was so ascribed when death occurred before surgery was possible, during or immediately after surgery or in the first twenty-four hour period after surgery when clinical data incidated a failure of the circulatory system to become stabilized. Where autopsy records were available in no instance in this group were any other causes of death forthcoming. Overwhelming anaerobic infection as a cause of death occurred 15 times but it must be remembered that the diagnosis is based on clinical signs rather than on bacteriological data. Peritonitis and pneumonia rank relatively low as causes of death in contrast to former times; in all these cases the immediate postoperative period had been weathered and death supervened several days later. Anuria as a cause of death is a relatively newly recognized entity in this particular war and it is hoped that intensive research being carried on at present may throw some light on this baffling problem. Pulmonary embolism as a cause of death represents a fair number of cases and thus far is the first cause of death which seems in any way directly related to a compound fracture. Interestingly enough it occurred most frequently in femoral fractures. The embolus was in most cases of vascular origin but where autopsy material was available fat embolism in a few instances was described, presumably originating in the marrow of the fractured bone. There were three cases of blast injury to the lung confirmed by postmortem examination and six

cases ascribed to pulmonary edema. The latter term is not too well understood and in no instance could further illumination of the term be obtained by careful scrutiny of the records. The three cases of aspiration asphyxia and the case of morphinism can hardly be considered in compound fracture mortality statistics. Cerebral damage is listed in two cases and in each instance certainly outweighs the effect of the long bone fractures as a cause of death.

There remain four cases of uncomplicated compound fracture of the femur in all of which death can be ascribed to the fracture per se. In three of these shock is ascribed as the cause of death and in the fourth pulmonary embolism was proved by postmortem examination and the source of the embolus was shown to be in the femoral vein on the involved side. All four of these cases are presented in detail.

Case 1.

A prisoner of war, age 38, was tagged 1000 hours, 12 January 1944 at a Collecting Company near the Cassino front. No knowledge of the exact time of injury was indicated on the record but the patient was found in poor condition in the open. Four hours later at another Collecting Company a splint was applied to the right lower extremity and morphine was given. One and one-half hours later the patient was received at a Field Hospital where blood and plasma were started. The patient was in very poor condition, pulse and blood pressure were not obtainable. Examination at the time revealed a fracture, compound, comminuted of the upper right femur and through and through wounds of the right upper thigh with marked soft tissue damage. There was no evidence of anaerobic infection. After five hours of intensive fluid replacement the blood pressure failed to rise above 58/30. Debridement and immobilization were done under ether-oxygen anesthesia. Shortly after returning to the postoperative ward the patient ceased breathing. Autopsy was done but failed to reveal any additional pathological change.

Case 2.

A 23 year old American officer was tagged for injury at 2115 hours, 26 May 1944 at a Battalion Aid Station, one hour and fifteen minutes after sustaining severe shell fragment wounds to the left thigh. Morphine was given and a Thomas splint and tourniquet were applied to the left lower extremity. The patient arrived at a Field Hospital eight and three fourths hours after injury but in the intervening hours the tourniquet had not been released. The patient was given 500 cc. of blood and two hours after arrival at the hospital was taken to surgery where the tourniquet was released. Fresh bleeding of the left thigh did not occur but the entire limb began to flush and the skin became pink and warm. During debridement under endotracheal gas-oxygen-ether

anesthesia only small branches of the femoral artery required ligation. During debridement and shortly after releasing the tourniquet, the blood pressure and pulse suddenly became unobtainable. With the aid of blood and plasma they were reestablished to fair levels at the close of the operation. The patient was returned to the postoperative ward where oxygen therapy was started. He improved rapidly but on the morning of the second postoperative day the patient developed circulatory embarrassment and died. Postmortem examination revealed thrombus formation extending from the left femoral vein into the common iliac vein. Massive emboli were found plugging the pulmonary arteries and extending back into the right ventricle.

Case 3.

An Italian civilian, age 13, was injured on 6 November 1943, time not stated, by a land mine. The patient was admitted directly to a Field Hospital where a compound fracture of the right femur, middle third, severe, was found. There were in association a minor compound incomplete fracture of the sacrum and minor wounds of the right buttock and arms. The patient was not in shock and apparently did not receive any supportive fluids. At 1130 hours, 6 November 1943 time lag not recorded, the patient was taken to surgery, where, under ether anesthesia, all wounds were debrided and the right lower extremity was immobilized in a Thomas splint using skin traction. At the close of the operation the patients pulse was 140/min. and associated with rapid shallow respirations. The anesthesia note stated the patient was conscious on leaving the operating room. The patient expired four hours postoperatively apparently because of progressive shock. Postmortem examination was not done.

Case 4.

An American infantryman, age 21, was injured 1 February 1945 at 0100 hours by small arms fire. The patient was tagged at 1200 hours on the same day at a Battalion Aid Station where he received two units of plasma, morphine sulphate grs. 1/4, and a Thomas splint to the right lower extremity. Admission to a Field Hospital occurred 16 hours after injury. At this time physical examination revealed a severe perforating wound of the right buttock with compound, comminuted fracture of the upper right femur. There were associated relatively minor wounds of the anterior chest wall, right leg and foot with an incomplete compound fracture of the os calcis. The abdomen and chest were normal on examination and the urine was clear. Although the record of this patient does not indicate the degree of shock, he received 1500 cc. of whole blood before operation. The blood pressure at the start of the operation was 118/70, pulse 110/min. Under endotracheal gas-oxygen-ether anesthesia, debridement of all wounds was effected with the patient on his left side. Gradually the blood pressure dropped to 80/50. The

patient was then turned to the supine position in preparation for a hip spica. Suddenly the blood pressure and pulse became unobtainable. Despite all efforts at resuscitation the patient could not be revived and was pronounced dead a few minutes later. Autopsy failed to reveal any further anatomical causes for death. The latter was ascribed to the original wounds and consequent shock.

CRANIAL INJURIES

THE INITIAL SURGICAL MANAGEMENT OF SEVERE HEAD WOUNDS

By far the majority of all cranio-cerebral wounds handled by this Group were operated upon by trained neurosurgeons with their teams. Excluding scalp lacerations, less than 1% of all operations done by general surgical or other specialty teams were cranio-cerebral operations. For the greater part of the period May 1943 to May 1945, three teams were adequate for the needs to be met by this Surgical Group. In the three month period, March-June 1944, four teams were active. For periods of not over a month at a time only two teams were active. This report is taken from the records submitted by those teams, working usually singly in Evacuation Hospitals.

The policy of the theaters in which this Group was active was to have the initial neurosurgery done in the forward Evacuation Hospitals. Here usually there were adequate space, lighting, and linens. Electro-surgical and suction apparatus were available. The hospitals were close enough to the fighting that time lag was not markedly increased by the time distance factor. Also, they moved less frequently than the Field Hospitals.

As a check on this policy, neurosurgical teams were placed in Field Hospital platoons acting as small mobile units supporting the division medical service. The Field Hospital platoon was set up next to the Clearing Station. Here the teams of this Auxiliary Surgical Group functioned in caring for priority and non-transportable patients. The proximity to the Clearing Station allowed for consultation in all head cases. Only non-transportable cases with head wounds were held for operation by the neurosurgical team at the Field Hospital, all others being sent back to the Evacuation Hospital. The experience of one team was as follows: Of 27 cases seen, six were held for operation; five died postoperatively. The sole survivor was transportable insofar as the cranial wound was concerned, but was held and operated on because of the severity of his associated wounds (Tinsley, Milton, 1945, submitted for publication). This experience indicates that the increase in time distance factor for evacuation to the next station in this Theater would not have influenced the eventual outcome in such extreme brain injuries.

The neurosurgical team usually furnished the only neurosurgeon with the Evacuation Hospital not staffed with a neurosurgeon. Although one team was sufficient with the usual flow of casualties, at times when a heavy flow of casualties or a concentration of neurosurgical cases was expected, two teams alternating on 12 hour shifts were used. This allowed better pre and post-operative care, with earlier surgery in the individual case. During much of the period only three teams were organized so that this practice could not be done as frequently as it might have been.

Cranial Surgery, 2nd Aux Surg Gp.

Since the team usually worked singly in the Evacuation Hospital, it was on 24 hour call. For this reason though most scalp wounds were seen, the team rarely cared for these cases unless there were signs of such magnitude to make one suspect intracranial complications.

Almost all cases operated on had either penetrating head wounds or depressed skull fractures. Records were kept of operations on about 40 closed head injuries, treatment of which did not differ from similar cases in civil life, therefore, they will not be discussed in this report. About 100 on patients with scalp lacerations were kept, most of which consist only of a brief note at the time of operation. No follow-up is available on these cases. Our subjective impression is that a fairly wide shaving and closure which includes the galea were the main factors for success in handling these cases.

Most cases were retained at the Evacuation Hospital for four to 10 days after operation. Rarely was it necessary to evacuate cases earlier than the third day, and serious cases not infrequently could be kept as long as 20 days after operation.

Follow-up notes after evacuation are incomplete. A single case was recognized in a published paper from a fixed General Hospital in the Zone of Interior. Other than this case the last progress reports are from within the Theaters. Knowledge of the final outcome of the surviving cases would be most desirable. Discussion here is limited mainly to what happened to patients with depressed skull fractures and penetrating head wounds operated on by the neurosurgical teams of this unit working usually in the Evacuation Hospitals.

Admission procedures were handled by the Evacuation Hospital staff through the admitting officer, who usually sent all surgical patients to a preoperative ward. Here, any emergency shock procedures were initiated by the ward officer who notified the team immediately of any emergency case. The neurosurgical team took responsibility for any cranio-cerebral case after notification until the patient was discharged. All other head cases were sent for x-ray examinations and the team notified. In mild to moderately severe head injuries with severe associated priority wounds, where craniotomy could safely be postponed, the associated injury was usually operated upon as soon as shock therapy was completed. In such cases the craniotomy was performed as a continuation of the associated operation if the condition of the patient at the end of this operation was satisfactory. At times the craniotomy was postponed for 48 hours or more, but could usually be done within 36 hours. All such cases were usually seen before the major associated injury was treated. Severe head injuries with severe associated wounds at times could not be operated upon at all, but where clinical

and x-ray examination could be accomplished and shock controlled, the lesion of major urgency as decided in consultation was first cared for. Almost all patients with scalp lacerations with unconsciousness were seen, and when neurological signs were present were operated upon and followed by the team. All but the mildest of associated injuries were operated upon by the general or specialty teams of the Evacuation Hospitals. When non-emergency cases were admitted after midnight the preoperative ward officer checked the patient's blood pressure and pulse, had the patient's head shaved and x-ray examination completed, and the team was notified of the admission in the morning. Some such routine is necessary with the team on 24 hour call.

DEPRESSED SKULL FRACTURES

Records are available on 120 depressed skull fractures of varying severity. The mildest showed local depressions a centimeter in diameter with no neurological signs. The most severe had marked depression of the inner table, up to eight centimeters in diameter, which tore the longitudinal sinus and contused the underlying brain over a fairly large area. The dividing line between this group and the penetrating head wounds depended on complete penetration of all layers of the dura.

TABLE I

Depressed Skull Fractures

	Cases	Extra dural	Sub dural	Intra-cere-bral	Venous sinuses	Fron-tal sinus	Dura Opened	Dura Closed	In-fec-tion	Con-vul-sions	Deaths
Shell fragment	81	6	5	4	5	5	22	12	5	1	4
Gunshot wound	17	2	0	0	0	0	5	3	1	0	1
Bomb fragment	4	0	1	0	1	0	2	1	0	1	1
Mine fragment	3	0	1	0	0	0	1	0	1	0	0
Grenade	2	0	0	0	0	0	0	0	0	1	0
Misc.	13	2	2	0	0	1	5	2	0	1	2
TOTAL	120	10	9	4	6	6	35	18	7	4	8

The dura was opened in 35 cases with abnormal neurological signs. Subdural or intracerebral hematomata were found in 13 instances. Most of the other cases had local cerebral contusions or lacerations, which

were usually debrided. These findings indicate that in such cases with focal or neurological signs the dura should be opened. In cases where the injury site was heavily contaminated, the subdural space was exposed through a nearby trephine opening. Only thus could the surgeon be satisfied that no operable cause for the signs had been neglected. Convulsions after operation occurred in at least four cases, or 3.3%, all focal and all controlled by phenobarbital. Infections occurred in seven cases or 6.5% of the group. Table II shows pertinent data on these seven cases.

TABLE II

Infections in Depressed Fractures

<table>
<tr><th>Case Number</th><th>Agent</th><th>Time lag</th><th>Wound</th><th>Dura</th><th>Associated injury</th></tr>
<tr><td>456</td><td>Shell fragment.</td><td>28 hrs.</td><td>Frontal clean.</td><td>Left open.</td><td>None.</td></tr>
<tr><td colspan="6">Comments:
Non-hemolytic staph albus eventually healed.</td></tr>
<tr><td>458</td><td>Shell fragment.</td><td>31 hrs.</td><td>Temporal.</td><td>Not opened.</td><td>Hemothorax left medial nerve.</td></tr>
<tr><td colspan="6">Comments:
5th day - Slight separation of wound edges.
12th day - Wound crusted over.
16th day - Crusts removed. Thin pus from under flap. Superficial inspissated pus in second area.</td></tr>
<tr><td>459</td><td>Shell fragment.</td><td>32 hrs.</td><td>Widely damaged scalp occipital.</td><td>Left open.</td><td>Minor pen. and perf. wounds of chest wall and shoulder.</td></tr>
<tr><td colspan="6">Comments:
All damaged scalp could not be debrided without major plastic closure.
2nd day - Sloughing.
7th day - Cerebral fungus. Fungus excised later.
29th day - Not yet healed, otherwise satisfactory.</td></tr>
<tr><td>483</td><td>Shell fragment.</td><td>14 hrs.</td><td>Oblique scalp entry with 6 x 3 cm. denuded fatty scalp layer occipital.</td><td>Closed.</td><td>Minor lacerated and pen. leg wounds.</td></tr>
<tr><td colspan="6">Comments:
All denuded scalp could not be debrided without major plastic closure. Pericranium and galea closed in overlapping fashion. Then skin margin sutured to fatty layer as split thicknass graft over galeal closure.
4th day - Slight drainage.
7th day - Superficial infected area, small. Follow-up definitely infected.</td></tr>
</table>

Cranial Surgery, 2nd Aux Surg Gp. (Table II, contd).

TABLE II

No. Cases.	Agent	Time lag	Wound	Dura	Associated injury
487	Mine fragment.	46 hrs.	Small pinched out forehead.	Not opened.	Traumatic amputation of leg - completed 1st. Many pen. face and nose wounds.

Comments:
Wound apparently communicated with face wounds, and all subcutaneous channels were not widely opened. Frontal sinus margin was seen but not opened.
3rd day - Sutures out: pus from lower end of incision and nasal wound on pressure. Follow-up - Frontal wound opened widely, developed osteomyelit here - eventually sequestrum was excised, and wound healed.

522	Gunshot wound.	27 hrs.	Right parietal gutter.	Closed.	None.

Comments:
4th day - Slight drainage from wound.
7th day - Wound reopened, seropurulent epidural pocket-granulation ov dura - dural suture removed epidural pack.
12th day - Evacuated.

551	Shell fragment.	18 days.	Right forehead wound draining pus, through frontal sinus.	Not opened.	Frontal sinuses both entered.

Comments:
Foreign body had been removed several days before admission. Osteomyelitis debrided. No postoperative notes or follow-up.

Infection could have been avoided by wide debridement and plastic closure in Cases Nos. 459 and 483, and either by leaving the wound open or by more thorough face wound debridement in Case No. 487. Case No. 551 had an infected wound when admitted.

Death occurred in eight cases in this series while under the observa tion of the operating team.

Cranial Surgery, 2nd Aux Surg Gp.

TABLE III

Deaths in Depressed Fractures

Case No.	Time Lag Hours	Admission BP/P/R	Agent	Examination	Dura	Day of Death	Comment Autopsy Findings
465	16	82/70 - -	Shell fragment.	Confused, negativietic pupils dilated, fixt. 7 cm. stellate mid line occipito-parietal laceration, spastic right arm. Neck mod. stiff.	Left open.	5th.	Died with hyperthermia. Multiple diffuse brain softenings, particularly in left parietal lobe and around the left ventricle.
473	Over 13	142/76 80 -	Gunshot wound.	Conscious, Severe hypersthesia of occiput, neck, shoulders, 4 cm. mid line frontal lacerated wound.	Not opened.	1st.	Never reacted from endotracheal ether anesthesia. Death of respiratory failure with clear airway. 1 cm. bipolar frontal softenings. Flame shaped 1 cm. long hemorrhage in upper cervical cord in posterior column, posterior horn, central gray matter, and spino thalamic tract.
493	18	110/70 120 24	Unknown.	Comatose, decerebrate, conjugate eye deviation to right. Left parietal lacerated wound neurological otherwise normal.	Left open.	1st.	Large subdural hygroma at operation. Brain showed diffuse small and large hemorrhages in cerebrum, cerebellum, and medulla.
513	33	130/80 126 24	Shell fragment.	Neurological normal.	Not opened.	1st.	FCC right tibia, pen. wound right thigh, with gas infection, amputated 6 hrs. after craniotomy. Died of gas infection 18 hrs. later, in deep shock.
524	13	- - -	Bomb	Stertorous hemoplegia Comatose, breathing, left pupils dilated and fixed. Multiple small wounds left parietal area.	Left open.	Day of operation.	30 c.c. subdural clot evacuated, underlying brain mushy, herniates. Was in very poor general condition in spite of 2 units of blood and 2 units of plasma. No autopsy.

Cranial Surgery, 2nd Aux Surg Gp. (Table III, contd).

TABLE III

Case No.	Time Lag Hours	Admission BP/P/R	Agent	Examination	Dura	Day of Death	Comment Autopsy Findings
525	3 days	160/80 68 22	Shell fragment.	Semicomatose, pupils sluggish. 7 cm. left temporal laceration with foul smelling pus exuding. Battle's sign on right, ecchymosis of left eye.	Not opened.	2nd.	Moderate extradural hematoma at operation. Slight subdural hematoma at autopsy. Marked softening of left posterior temporal and parietal lobes, with cortical contusion and laceration. 0.5 cm. posterior dorsal meso-encephalic hemorrhage.
566	18	120/70 54 30	Shell fragment.	Comatose, pupils dilated, left fixt. moves no extremities, 7 cm. mid line frontal laceration.	Left open.	Day of operation.	Sagittal sinus found torn at operation; dura tense, dark, bulging on both sides, attempted exploration for subdural encountered severe bleeding from sagittal and contributing sinuses. Closure after control of hemorrhage without another exploration. Autopsy showed thin widespread subdural clotted blood.
567	8	112/60 120 24	Fall.	Comatose elderly prisoner, restless moves all extremities. 5 cm. triangular dirty scalp lacerations in left occipital region.	Not opened.	3rd.	Dura pulsating at operation, not opened. Never regained consciousness. Autopsy showed moderate destruction of the left occipital lobe.

Two deaths were due to associated injuries; in Case No. 473, there was an upper cervical cord hemorrhage, with neurological signs which were considered to be only a nerve root concussion, Case No. 513 died of gas gangrene of the legs. Death in the other cases was due to massive brain damage, particularly in the brain stem.

SUMMARY OF DEPRESSED SKULL FRACTURES

1. One hundred and twenty case records were reviewed, with seven infections and eight deaths.

2. There are four recorded cases of convulsions after operation, all Jacksonian in type, and all controlled by phenobarbital.

3. The dura was opened in 35 cases, in 19 of which it was not closed.

4. The dura should be opened in any case with neurological signs. In this series nine subdural hematomas 25.7% and four intracortical hematomas 11.4% were noted in the 35 cases where the dura was opened. In addition, mushy lacerated and contused brain, which could only have produced scar tissue, was evacuated.

PENETRATING HEAD WOUNDS

Records are available on 454 penetrating head wounds. These varied in magnitude from the tiniest complete dural tear resulting from a depressed skull fracture to massive penetrating and gutter wounds. There were 63 deaths in the series, 11 from infection. Fifteen infected cases, including superficial wound infections, were evacuated. There were 29 wound disruptions, from tiny cerebro-spinal fluid leaks to major disruptions with cerebral hernias.

Cranial Surgery, 2nd Aux Surg Gp. (Penetrating Head Wounds, contd).

TABLE IV

Time Interval in Penetrating Head Wounds

Average Time Interval 19.3 hours

Time Lag Wounding to Operation in Hours	No. Cases	No. Deaths	Percent Mortality	Dis-rupted	Infec-tion	Sulfa	Penici-llin	Sulfa an[d] Penici-llin
Under 12 0 - 12	185	25	14%	8	6	30	33	0
Over 12 12 - 18	74	7	9%	6	5	12	21	1
Over 18 18 - 24	70	10	14%	4	4	12	18	1
Over 24 24 - 48	77	18	23%	7	7	10	17	0
Over 48	35	3	11%	4	4	4	6	1
Not Specified	13	0	0%	0	0	0	0	0
TOTAL	454	63	14%	29	26	68	95	3

Time Interval.

Over half of the cases, 259,,were operated upon less tha 18 hours afte[r] injury. The average time lag between injury and operation was 19 hours and 18 minutes. In arriving at this average the 48 cases operated upon after 48 hours were considered as having been operated on then. Due to the fact that teams were usually on call 24 hours a day, only the more serious cases arriving after midnight were operated upon before eight o'clock the next morning. Since it was possible to do only one case at a time, the more seriously ill case, if ready for operation, was done first unless decerebrate. (Cases decerebrate on admission are discussed under deaths).

Wounding Agents.

Shell fragments caused by far the largest number of head wounds, accounting for 347 cases. Small arms fire produced 77. Thirty-two shell fragments (9.2%) perforated the head, while 29 bullets (37.7%) traversed the calvarium.

TABLE V

Wounding Agent in Penetrating Head Wounds

In 64 Cases no Notes Were Available as to Whether Foreign Body Was Present, Absent, or Removed

	Shell Fragment	Gunshot Wound	Mine Fragment	Bomb Fragment	Grenade	Misc.	Total
Penetrating	315	48	11	6	2	11	393
Perforating	32	29	0	0	0	0	61
No foreign body	74	47	2	2	1	10	138
Foreign body retained	116	11	3	2	1	0	133
Foreign body removed	96	18	3	1	0	1	119

Artillery shell fragments produced a variety of wounds. There was the small depressed fracture with small foreign body in the skull, dural tear and minimal brain damage. Large block depressions of the skull were seen, caused usually by a large slow velocity shell fragment, with small dural tear and superficial underlying brain damage. The gutter wound was frequent, with severe dural and brain damage due to vertically indriven bone chips, but no foreign body. The typical true penetrating wound showed a puncture-like wound of entrance, indriven hair and bone in single or multiple tracts, and a retained intracerebral foreign body. The perforating head wound showed entry and exit wounds, or entry wound and extracranial foreign body, with a brain tract containing bone chips, hair and debris.

Mortar fragments usually did not perforate, and such wounds were frequently complicated by a fair amount of cerebral commotion or blast effect.

Small arms fire usually produced a gutter wound, perforating wound, or puncture-penetrating wound. With ricocheted or spent bullets one saw the depressed fracture type.

Mine, bomb, and grenade wounds were usually of the puncture-penetrating type, but more rarely produced the gutter-type wound. With these agents the patient almost invariably showed some evidence of cerebral commotion due to blast.

Cranial Surgery, 2nd Aux Surg Gp. (Penetrating Head Wounds, contd).

State of Consciousness.

The main criterion of seriousness in a given case was the state of consciousness, as shown in Table VI where noted. There are a number of duplications, as agitated patients were conscious, semi-conscious or comatose, and all decerebrate patients were comatose.

TABLE VI

State of Consciousness in Penetrating Head Wounds

	No. Cases	No. Deaths	Percent Mortality	Pen.	Perf.	Ventric	Cerebellar	Ven. Sinus	Arteries	Herni
Conscious	227	10	4%	202	25	22	2	8	3	62
Semi-consciousness	85	6	7%	73	12	12	2	2	2	30
Comatose	92	44	48%	71	21	18	1	9	5	37
Agitated	53	8	15%	41	12	2	0	4	0	24
Debrebrate	13	12	92%	10	3	3	0	1	0	8

Herniation of brain on admission was more frequent than is indicated on the table, as in cases where it must have been present (from other indications in the record) it was not recorded.

Neurological signs gave further indication as to the seriousness of the wound. In the comatose patient some findings could not be determined or were not recorded. Although lesions of the anterior portion of the frontal lobes and the infero-lateral temporal lobes produced no localizing signs, damages elsewhere produced well-known clinical patterns. Only six peripheral cranial nerve lesions were noted, four which involved the auditor nerve.

Isolated speech handicaps, monoplegias, hemianopsias, either partial or complete, were produced by small lesions. Larger lesions showed triplegias, tetraplegias, and mixed motor, sensory visual and speech losses. The most grave cases showed decerebration, dilated fixed pupils, Cheyne-Stokes respirations with hyperthermia and hypertension.

Cranial Surgery, 2nd Aux Surg Gp. (Penetrating Head Wounds, contd).

TABLE VII

Neurological Findings in Penetrating Head Wounds

		No. Cases	No. Deaths
1. Monoplegia			
Leg	Right	4	1
	Left	3	0
Arm	Right	2	0
	Left	4	1
2. Hemiplegia			
	Right	77	10
	Left	56	8
3. Paraplegia			
	Leg	2	1
	Arm	1	0
4. Triplegia		8	3
Anesthesia			
Arm	Right	2	0
	Left	5	0
Leg	Right	1	0
	Left	2	0
Hemi	Right	9	0
	Left	11	1
Aphasia		55	3
Eye Deviation		19	5
Dilated Pupils			
	Hemolateral	9	3
	Contralateral	2	0
	Bilateral	24	8
Cheyne Stokes		8	3
5. Tetraplegia		9	9

X-rays were very valuable in determining the amount og damage. Stereoscopic films were rarely made, but were of help in special cases. We were impressed by the fact that the X-ray tended to minimize the extent of the skull lesion. Also, repeatedly many more bone fragments were removed at operation than one suspected from the X-ray films.

Associated Injuries were recorded in 30% of cases. They were considered mild in 17.2% and moderate to severe in 12.8%.

TABLE VIII

Associated Injuries and Shock in Penetrating Head Wounds

Shock	Associated Injuries			
	None	Mild	Moderate to Severe	Total
Survived				
None	204	46	15	265
Mild	53	14	11	78
Moderate to severe	22	9	17	48
Deaths				
None	14	5	4	23
Mild	11	2	4	17
Moderate to severe	14	2	7	23
TOTALS	318	78	58	454

Shock was recorded as present in 36.6% of cases. Mild shock was diagnosed if the systolic blood pressure was above 80 but below 100 and the pulse pressure was over 30 mm. of mercury, provided that the systolic pressure was restored to 100 or above with one or two units of plasma. All patients who received plasma in amounts of not over two units before admission and no blood were considered to have mild shock, if no blood and not over two units of plasma altogether were necessary before operation.

A patient with a systolic blood pressure of less than 80, or a pulse pressure of less than 30, or who received blood, or a total of over two units of plasma altogether was considered to have moderate to severe shock.

Mild shock as diagnosed above was recorded in 20.9% of cases, while moderate to severe shock occurred in 15.6% of patients.

The shock associated with head injuries was due to blood loss and was comparatively mild. This form of shock was easily combatted with small amounts of plasma, blood or fluids. Severe shock as seen in patients with wounds elsewhere was rarely seen in uncomplicated cranial injuries. The shock-like condition which occurs in decerebrate states is discussed more fully under deaths.

Severe head injuries exhibited signs related to embarrassment of the vital cerebral centers, with hypertension, increased pulse pressure, slow pulse, cyanosis, and rising temperature. This state was usually due to increased intracranial tension, which could be relieved, if at all, by surgery.

Anesthesia varied according to the preference of the surgeon, and the preference, ability, and availability of the anesthetist. There was an overall shortage of physician anesthetists and widely trained nurse anesthetists throughout the Surgical Group from time to time. Since the neurosurgeons were accustomed to operating under local anesthesia, it was thought that they could manage better without an anesthetist than could some other teams. For this reason the number of cases done under local anesthesia alone was a bit larger than if free choice of agents were always available. In the presence of severe associated wounds or of nasopharyngeal bleeding endotracheal ether was the anesthesia of choice. Agitation required some form of general anesthesia. Quiet coma with serious general condition made one prefer local. Minor associated wounds were frequently operated on under pentothal after craniotomy under local anesthesia. The objection to local, that it produces psychic trauma in the conscious patient, can be neutralized to a large extent by a barbiturate in addition to the routine morphine before operation, thus making the patient drowsy and somnolent. This of course can also be accomplished with repeated small doses of pentothal. The other objection to local anesthesia is the constant temptation for the operator to minimize the amount of surgery done, with resultant incomplete debridement. The scalp is readily anesthetized with local, but large amounts were required for lengthy formidable procedures. As much as 300 c.c. of a 1% solution was used in some cases, without apparent adverse effect, but the wisdom of such large doses might justifiably be questioned.

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TABLE IX

Anesthesia in Penetrating Head Wounds

	Local	Pentothal	Local and Pentothal	Endo-tracheal Ether	Percent Mortality	No. Death
Conscious	130	11	47	39	4%	10
Semi-conscious	39	5	31	10	7%	6
Comatose	59	1	16	16	48%	44
Agitation	16	2	19	16	15%	8
Decerebrate	11	0	1	1	92%	12
Total	255	19	114	62		
Deaths	54	1	11	14		

Pentothal alone was used infrequently, in 4.6% of cases. Except for very short procedures, such as debridement and drainage of an infected small penetrating wound, it is advisable to use local also, or to use ether. Nitrous oxide, because of its anoxic factor, was used only as an induction agent before endotracheal ether, or rarely in low concentration with high oxygen mixtures for short continuation after it was deemed unwise to give more pentothal.

Operative procedures varied little from those in civil injuries. The scalp was shaved widely. Soap, water, and ether were used for cleansing. Either iodine and alcohol or mercurial antiseptic were used for scalp preparation. All non-viable skin was debrided, even if a shifting flap closure with or without grafts were necessary. Tripod incisions were avoided where possible, extension by curvilinear and flap incisions being preferred. Damaged pericranium was debrided liberally, and the bony defect enlarged to expose the dural margins. Dural debridement was rarely found to be necessary. Brain tracts were followed, usually by direct vision with plain or lighted retractors, using the suction to debride and keep the field dry. Bone chips were almost invariably found caught in a net of blood vessels, which could be clipped or coagulated as they were exposed. Foreign bodies readily exposed were removed. In some cases the electro magnet or probe were used for location of foreign bodies, but in the majority of cases remote foreign bodies not seen were not removed.

Usually at this stage the brain was no longer tense, the tract tending to gape. If such were not the situation, other intracranial blood collections were suspected. Not infrequently, particularly when the entry wound was small, exploration of the subdural space on the same side yielded sufficient old blood to produce the desired relaxation. In some cases, particularly those with very distant foreign bodies on the same or the

opposite side, counter incisions exposed subdural or intracerebral hematomas.

Osteoplastic craniotomies were done in 13 cases or 2.9%. Orbital roof fractures, cerebrospinal rhinorrheas, and contralateral explorations for retained foreign bodies were the only indications.

Dural closures, with or without pericranial, fascia lata, or preserved dura grafts, were a matter of individual decision.

Scalp closures were usually made in two layers with interrupted fine silk. Necessity for haste in view of the condition of the patient, or because of the time factor when the operative load was heavy, occasionally resulted in interrupted through-and-through closure, but under these circumstances the galea was always included. Tension with resultant ischaemia and later slough was the main cause of wound disruptions. For this reason liberal enlarging incisions with wide undermining, counter incisions, large plastic flaps, and galeal incisions beneath the flap proved of help. Relaxing incisions had to be placed at least seven cm. from the wound to avoid ischaemia of the strip between, the galea had to be freed from the underlying pericranium between wound and incision and around both, and the relaxing incision had to be at least half as long again. Incisions so used were placed so that the major arteries were not severed. Sliding flaps about three times the size of the defect to be covered were freed, the wound closed and if the flap could not be sutured over the denuded pericranium, Thiersch grafts with vaseline gauze moulage for pressure were sutured over the resultant defect (Balkin S; Dowman, C.E.; Klemperer, W.W.; J.A.M.A., Vol. 128, Page 70 , 12 May 1945).

Drains were employed by some surgeons in some cases. Intradural drains were eventually abandoned by all. Epidural packs were used by one surgeon in all frontal and ethmoid sinus and mastoid complications.

Chemotherapy was not employed inside the dura by two surgeons. Others used both sulfanilamide crystals and penicillin intracerebrally.

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TABLE X

Closure and Chemotherapy in Penetrating Head Wounds

	Scalp and dura closed, no drain.	Scalp and dura closed, drained.	Scalp closed, dura open, no drain.	Scalp closed, dura open, drained.	Scalp open dura closed	Scalp open, dura open.	TOTAL
No Chemotherapy							
Cases	103	31	129	12	3	11	289
Infection	4	0	14	0	0	3	21
Disruption	3	0	22	1	0	0	26
Deaths	9	5	26	2	2	3	47
Sulfa							
Cases	22	14	11	19	0	1	67
Infection			1	1			2
Disruption	1		1				2
Deaths		1	2	5			8
Penicillin							
Cases	80	4	10	0	1	0	95
Infection		1	2				3
Disruption	1						1
Deaths	5	1	2				8
Penicillin & Sulfa	2		1				3

Postoperative Care.

All nursing care was furnished by the Evacuation Hospital personnel under the supervision of the surgeon and assistant surgeon of the team. Overactive patients were sedated when their activities were such as to be a danger to themselves and restraints had to be employed at times for the same reason. Frequent turning and tracheal catheter aspiration helped in prevention of bronchopneumonia in the comatose patient. One surgeon kept all patients' heads elevated. No surgeon restricted fluids. Comatose or agitated patients were given fluids by vein or stomach tube. Most patients were kept in bed. A few hospital type beds when available were of great

help in the care of unconscious and agitated patients.

Patients ideally were retained at the Evacuation Hospital for four to 10 days when the tactical situation permitted. When more rapid evacuation was necessary every effort was made to send the patient directly to a hospital staffed with a neurosurgeon. One objection to doing neurosurgery in the Field Hospital is the necessity for frequent moves, leaving patients behind with a holding group. There are not enough neurosurgeons to leave one behind with each small group of patients.

During the postoperative period, the blood count or hematocrit was determined and blood replacement given to return the red blood count to 4,000,000 or the hematocrit to 35%. All patients were given sulfadiazine by mouth or vein before penicillin was made available (June 1944). Thereafter all patients received penicillin intramuscularly. During quiet periods it was possible to do dressings as frequently as indicated, and at the desired times. During periods of heavy casualty load, dressings were done at odd hours and infrequently. Ideally, the surgeon kept each patient until all sutures were removed.

Infections.

There were 26 infections noted in the entire group and 11 of these cases died. The coli-aerogenes group was responsible for most deaths. The organism in survivors was usually staphylococcus or pneumococcus, though a few of the coli group also survived. Diagnosed infections also included superficial wound infections. The total incidence of infection while under observation by the teams is given in Table IV. Table X shows the relationship of closure and chemotherapy to infection. Table XI shows infections among survivors, and the type of wound and agent.

TABLE XI

Infections Among Survivors of Penetrating Head Wounds

	No. Cases	Infections	Percentage
Total Cases	391	15	3.8%
Penetrating	339	13	3.8%
Perforating	52	2	3.8%
No foreign body	118	5	4.2%
Foreign body retained	108	1	0.9%
Foreign body removed	108	6	5.6%
Shell Fragment	290	11	3.8%
Gunshot wound	65	4	6.2%

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Deaths.

Sixty-three patients died while under observation of the operating team, a mortality rate of 13.9%. This rate is artifically low, as at times patients had to be evacuated who would have died in our hands in a few days. Table VI, in spite of its duplications, shows that although half of all patients were conscious, rational and quiet, only 15.9% of all deaths occurred in this group, and the mortality in this group was 4.4%. State of consciousness on admission, therefore, is of definite prognostic significance. Anesthesia deaths were so rare as not to have been recorded in this series. This may be because the neurological status so outweighs the ordinary manifestations of anaesthetic death. Table XII shows the wounding agent, type of wound, and foreign body history on all deaths.

TABLE XII

Deaths in Penetrating Head Wounds

	No. Cases	No. Deaths	Percentage
Total Cases	454	63	13.9%
Shell fragments	347	50	14.4%
Small arms	77	12	15.6%
Mine fragments	11	1	9.1%
Not perforating	393	54	13.7%
Perforating	61	9	14.8%
No foreign body	136	18	13.2%
Foreign body retained	132	25	18.9%
Foreign body removed	119	11	9.2%

The most serious cases were those which arrived comatose and decerebrate; in spite of all surgical efforts they died. Due to this result no case of decerebration was operated if a more favorable case was ready for operation. Thirteen operations were performed on decerebrate cases and one survived. This patient, Case No. 402, was admitted 12 hours after wounding, and showed a perforating bullet wound from right frontal to right temporal regions, herniating brain. He alternated between quiet and agitated coma, with spasmodic spastic extension of all extremities during the agitated phases. The left leg did not move except in the attacks. Blood pressure 150/58, Pulse 32, Respirations 40-48 and Cheyne Stokes in character. At operation under endotracheal ether three hours after admission a ten by four by eight centimeter defect of the right frontal and temporal lobes was produced by debridement. Three days later he talked, had a paralyzed left leg, and was having midbrain seizures. This is the last available note on this interesting patient. Since he was a German Prisoner of War it is probably the last we shall ever know.

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Hematomas.

In the hematoma group death occurred in 12.1% of cases. Parasagittal subdural hematoma was found at autopsy in one case with a wound traversing both hemispheres. One patient who died had a large undiscovered subdural hematoma on the side of the entry wound at autopsy; thereafter, in any patient where pressure was not relieved by tract debridement the subdural space was explored homolaterally or bilaterally. One patient had a large contralateral subdural hematoma evacuated, and at autopsy showed a large contralateral intracerebral hematoma. The fourth patient with subdural hematoma also had damage to the basal ganglia which proved fatal. One patient with an intracerebral hematoma who died is discussed with the subdural group. The other had cerebral anaerobic infection at the time of operation. The patient with the epidural hematoma also had fatal basal ganglier damage.

TABLE XIII

Hematomas in Penetrating Head Wounds

	Survived	Died	Total
Extradural	11	1	12
Subdural	22	4	26
Intracortical	18	2	20

Intracranial complicating wounds were fairly common, as is shown in Table XIV. There are of course many duplications here, particularly in the air sinus and orbit groups, as these are frequently all affected in a single case.

Ventricular injuries were recorded in 52 cases or 11.4% of the series. The scalp was closed tightly in all cases. In 20 cases the dura was left open; one case became infected but survived, while nine died. The dura was closed in 32 cases with no infections among survivors and eight deaths. Operative treatment was not modified because of this complication.

Major cerebral artery lesions occurred in 10 cases, with five deaths. In all, the arterior cerebral artery had been involved.

Venous sinuses were torn in 26 cases. The sagittal sinus was completely torn in 10 instances with five deaths; it was partially torn in 14 cases with two deaths. The lateral sinus was partially torn in two instances with no deaths. Bleeding from these sinuses was controlled by ligation, silver clips, muscle, fibrin foam, or a combination of

Cranial Surgery, 2nd Aux Surg Gp. (Hematomas in Penetrating Head Wounds, contd).

with electro-cautery.

Air sinus or mastoid wounds complicated 78 cases, with 12 deaths. One mastoid wound became infected. The relatively low death and infection rate in this group was obtained because every effort was made to wall off the air cavity from the subarachnoid space. Dural repairs were accomplished wherever possible, and where this could not be done muscle stamps, pericranial stamps, or fibrin foam were used to encourage rapid sealing of the cerebrospinal fluid leak.

Involvement of the basal ganglia proved to be quite lethal, with only one survivor in 16 cases.

TABLE XIV

Complicating Intracerebral Wounds in Penetrating Head Wounds

	Survived Clean	Survived Infection	No. Deaths	Total
Orbit	25		5	30
Frontal sinus	41		6	47
Ethmoid sinus	12		4	16
Sphenoid sinus	3		1	4
Mastoid	9	1	1	11
Ventricle				
Dura closed	24		8	32
Dura open	10	1	9	20
Basal ganglia	1		15	16
Cerebellar	6	1	1	8
Arteries	5		5	10
Sagittal sinus				
Partial	12		2	14
Complete	5		5	10
Lateral sinus				
Partial	2			2

Involved lobes of the brain are shown in Table XV. Some of the reco[rds] are rather incomplete, so that a case showing single lobe entry may have had other lobes involved as well. Only entry site is shown on some record and no description of the x-ray findings or exact point where the foreign body lay is available.

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TABLE XV

Involved Lobes of the Brain in Penetrating Head Wounds

	Survived		Deaths	Total
	Wound Clean	Wound Infected		
Frontal only				
Unilateral				
Right	41	2	8	51
Left	61	0	9	70
Bilateral	19	2	3	24
Parietal only				
Unilateral				
Right	23	1	6	30
Left	58	2	10	70
Bilateral	3	0	0	3
Temporal only				
Unilateral				
Right	26	2	3	31
Left	25	1	4	30
Bilateral	2	0	0	2
Occipital only				
Unilateral				
Right	23	1	2	26
Left	17	1	2	20
Bilateral	0	0	1	1
Fronto-parietal				
Unilateral				
Right	9	1	2	12
Left	14	0	0	14
Bilateral	0	0	2	2
Three lobes	8	0	0	8
Four lobes	1	0	0	1

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TABLE XV

	Survived		Deaths	Total
	Wound Clean	Wound Infected		
Fronto-temporal				
Unilateral				
Right	6	0	0	6
Left	2	0	0	2
Bilateral	0	0	2	2
Three lobes	3	0	2	5
Fronto-temporo-occipital				
Bilateral				
Three lobes	1	0	0	1
Fronto-parietal temporal				
Unilateral				
Right	2	0	0	2
Left	0	0	1	1
Bilateral				
Three lobes	3	0	0	3
Four lobes	1	0	0	1
Fronto-parieto-occipital				
Unilateral				
Right	2	1	1	4
Left	0	0	0	0
Bilateral				
Three lobes	2	0	0	2
Four lobes	0	0	1	1
Five lobes	1	0	1	2
Temporo-parieto-occipital				
Unilateral				
Three lobes	4	0	0	4
Fronto-temporo-parieto-occipital				
Unilateral				
Right	1	0	1	2

Cranial Surgery, 2nd Aux Surg Gp. (Table XV, contd).

TABLE XV

	Survived		Deaths	Total
	Wound Clean	Wound Infected		
Fronto-occipital				
Bilateral	0	0	1	1
Parieto-temporal				
Unilateral				
Right	2	1	0	3
Left	6	0	1	7
Parieto-occipital				
Unilateral				
Right	2	0	0	2
Left	4	0	0	4
Bilateral				
Two lobes	1	0	0	1
Three lobes	1	0	0	1
Temporo-occipital				
Unilateral				
Right	1	0	0	1
Left	1	0	0	1

SUMMARY OF PENETRATING HEAD WOUNDS

1. Four hundred and fifty-four records of penetrating head wounds are reviewed. There were 63 deaths, the wounds of 11 of which were infected. Fifteen cases with infected wounds survived.

2. The average time lag was 19 hours and 18 minutes. Over half of all cases were operated less than 18 hours after woundings.

3. Shell fragments caused 347 wounds, of which 32 were perforating. Small arms fire caused 77 wounds, 29 of which were perforated.

Cranial Surgery, 2nd Aux Surg Gp. (Summary, contd).

4. State of consciousness was of definite prognostic significance. Half of all patients were conscious, rational and quiet; only 4.4% of these died. Twenty and four-tenths percent of the cases were comatose, and 47.8% of these died.

5. Tetraplegias, mid-brain seizures, dilated fixed pupils, and Cheyne-Stokes respiration were grave prognostic signs.

6. Peripheral cranial nerve palsies were rare.

7. Mild associated injuries occurred in 17.2% of cases. Moderate to severe associated injuries were present in 12.8% of cases.

8. Mild shock occurred in 20.9% of cases, while moderate to severe shock occurred in 15.6% of cases.

9. Shock in uncomplicated head injuries was usually mild. Moderate to severe shock was recorded in 19 of 288 cases having no associated injuries, a frequency of 6.2%.

10. Local anesthesia alone was used in 255 cases, pentothal alone in 19 cases, local and pentothal in 114 cases and endotracheal ether in 82 cases.

11. Decompressive craniotomy was used in 441 cases. Osteoplastic craniotomy was performed in only 13 cases.

12. Remote foreign bodies were rarely removed. The electro-magnet was used infrequently.

13. Debridement was mainly directed toward removal of all organic indriven matter, devitalized brain and extravasated blood.

14. All devitalized scalp, galea, and pericranium were usually excised.

15. Procedures in scalp closures were directed toward preservation of blood supply and avoidance of tension.

16. The dura was closed in 257 cases, with 22 deaths, four infected survivors, and five wound disruptions. It was left open in 197 cases with 41 deaths, 11 infected survivors, and 24 disruptions.

17. Ninety-six cases were drained with 20 deaths and 11 infected survivors.

18. Local chemotherapy was used in 165 cases, with 47 deaths, 21 infections, and 26 disruptions.

19. The venous sinuses were involved in 26 cases with seven deaths.

20. Major cerebral arteries were involved in 10 cases with five deaths. In all deaths the anterior cerebral artery was involved.

21. Intracranial hematomas occurred in 58 cases, with seven deaths.

22. The ventricle was open in 52 cases, with 17 deaths.

23. The basal ganglia were damaged in 16 cases with 15 deaths.

24. The air sinuses were involved in 78 cases, with 11 deaths and one infection.

CONCLUSIONS

1. The Evacuation Hospital is the place of choice for forward cranial surgery.

2. Ideally, it is advantageous to have two neurosurgical teams alternating on 12 hour shifts in the same hospital.

3. The subdural space and underlying brain should be exposed in all depressed skull fractures where abnormal neurological signs exist, and in other cases where the dura is tense and discolored and does not pulsate.

4. The state of consciousness on admission is of definite prognostic significance.

5. The concussive force of the wounding agent on the brain increases the severity of the brain damage.

6. Shock is not a problem in uncomplicated head wounds.

7. Decompressive craniotomy is the procedure of choice in war wounds of the cranium.

8. Thorough debridement of damaged brain, extravasated blood, and all indriven organic matter is the single most important factor in prevention of infection.

Cranial Surgery, 2nd Aux Surg Gp. (Conclusions, contd).

9. Intracranial hematomas should be suspected where adequate debridement has not relieved the increased intracranial tension.

10. Head wounds complicated by air sinus involvement are not formidable.

11. The scalp should be closed in all uninfected cases regardless of time interval or amount of scalp loss.

12. Hospital type beds are invaluable in aftercare of comatose and agitated patients.

MAXILLO-FACIAL INJURIES

PART I

IN THE FORWARD HOSPITALS

TREATMENT OF MAXILLO-FACIAL INJURIES IN FORWARD HOSPITALS

The cases that form the basis of this study were taken from records submitted by teams of the 2nd Auxiliary Surgical Group and cover a period from June 1943 to May 1945. These casualties were incurred in Africa, Italy, and Southern France.

Mutilating wounds incurred in the first World War were characterized by their extensive loss of bony and soft tissue, delayed secondary closures, prolonged periods of convalescence and repeated esthetic operations. Success of reparative surgery is dependent upon the skill of the operator and the availability of the tissue with which to work. It is this letter factor which may be altered favorably by a change in the technical procedures in the forward hospital installations.

For all practical considerations Maxillo-Facial cases may be handled in Evacuation Hospitals and it is only the exceptional case that cannot be adequately treated for shock and impaired airway in forward units to make rapid evacuation to the rear reasonable. By this triage the patient has advantage of all the facilities of surgical and dental departments as well as their trained oral and plastic personnel. By this fortunate combination of material and skill, the patient may expect the most promising results in the field of functional as well as esthetic results.

Briefly stated, the most radical changes in procedures developed during this war are: (1) The immediate closure of all facial wounds; (2) Extreme conservation of both soft and bony tissue; (3) Immediate reduction and immobilization of fractures; (4) Prophylastic use of the sulfonamides and penicillin.

With these principles carried out to their maximum extent the patient should reach the hospital in the rear in excellent condition, infection should be insignificant, and tissue loss minimal, and as a result of primary closures much of the reconstructive surgery of the Base Hospitals will become unnecessary.

PREOPERATIVE PROCEDURES

Pre-Evacuation Hospital Treatment

Therapy given by Battalion Aid Stations and Clearing Stations must of necessity be limited, and should go no further than the following procedures:

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Haemostasis.

In spite of profuse arterial supply to the face and neck it is only the rare case that reaches the forward Aid Stations in need of haemostats or sutures. Pressure dressings will usually suffice and mitigate against further contamination of the wound which would result from extensive haemostatic procedures.

Airway.

Maintenance of a clear respiratory tract may be accomplished by tracheotomy, metal airway, extension of the tongue, and by postural drainage.

Shock.

In extensive facial injuries with involvement of bone, shock is primarily due to loss of blood. Shock as a result of hemorrhage is best controlled by the administration of whole blood. Blood pressure readings will give an adequate index as to the degree of shock and efficiency of treatment. There is little or no danger of overloading the system as might be expected in cases of thoracic or cardiac injuries. (See page

Therapy.

Due to mechanical respiratory difficulties in many of these cases it is wise to give morphine sparingly and in no case is it advisable to give more than 1/4 grain every four hours.

Prophylactic therapy may consist of tetanus toxoid and oral or intravenous sulfadiazine.

The local application of sulfonamides may well be discontinued for it only incrusts the wound, its local action in the presence of blood and secretions is quite limited, and what absorption of the drug takes place is uncontrolled. The parenteral use of the sulfonamides is adequate when used in conjunction with penicillin in doses of 25,000 units every four hours. Under these circumstances it has become evident that local and general infections are well controlled.

Evacuation Hospital Treatment:

Shock.

The time lag between administration of emergency treatment to the casualty and admission to an Evacuation Hospital may range from two to as much as 20 hours. Under these circumstances varying degrees

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of secondary shock may develop and it is with this variety of shock that the Evacuation Hospital is most concerned. Treatment is limited to the administration of fluids to restore the blood volume and should be accomplished by the introduction of whole blood, plasma, and glucose-saline solution. Solutions or drugs tending to draw tissue fluids into the vascular system are not indicated.

In the average maxillo-facial case immediate surgery is not imperative and in the presence of haemostasis, clear airway, and a reasonably comfortable patient, it is wise first to reduce shock to a minimum. Many cases will require time-consuming operative procedures under general anesthesia and therefore surgery should be attempted only under controlled conditions. Much can be accomplished at this time by detailed surgery which will in many cases eliminate multiple secondary operations.

Continued shock therapy during operative procedures is frequently a requisite. It will also permit prolongation of operative time well beyond ordinary limits. The average blood administration per case was found to be only 125 c.c. per patient in addition to 100 c.c. of plasma, (i.e. - One in four patients received one unit of blood). When associated injuries are deleted from this study it becomes obvious that only the occasional maxillo-facial case is in severe shock when admitted to any hospital installation. Patients in shock from blood loss however, require vigorous and prompt blood replacement.

Physical Examination and X-ray.

Physical examination of patients with badly comminuted wounds of the face is difficult. This is due to the discomfort experienced by the patient during examination because of impaired airway, potential secondary bleeding and impaired oral functions. In many cases observation of the track of the missile will give all the information that is required. In the simpler forms of facial fractures the diagnosis may be made on the usual findings of deformity, pain on motion, crepitus and loss of tissue.

Preoperative diagnosis is best based upon x-ray findings. In practically all cases films can be taken in sufficient numbers to make an accurate diagnosis. Anterior-posterior and lateral views are generally sufficient for the mandible, maxilla and nasal bones. The Water's position will give good films in fractures of the orbit, entrum, zygoma and frontal sinuses.

Anesthesia.

Maxillo-facial cases of the severe variety may present indications for two types of anesthesia. Preoperative medication, shock therapy and

general supportive treatment can improve the patient's condition to a point where minor procedures and intermaxillary wiring may be done under procaine. It is felt however, that general anesthesia is indicated in cases requiring manipulation, those having bleeding into the mouth or oro-nasal cavities, and those in an apprehensive condition.

Few if any patients can be adequately handled by drop ether or by any other type of simple inhalation anesthetic. Only by the use of endo-tracheal tube and proper attachments can a clear operative field be obtained and the patient be properly protected against the hazards of aspiration and bleeding. The best results are obtained by passing the tracheal tube nasally since it gives the operator a completely clear oral field. If a reasonably small tube is used it need not be removed for 20 or more hours and will guarantee an adequate airway over a sufficient period of time to avoid, in most cases, the necessity for a tracheotomy.

Many simple facial fractures as well as a considerable proportion of compound mandibular and maxillary fractures may well be handled under Sodium pentothal. Of the 276 fracture cases 94 received endo-tracheal anesthesia while 102 received Pentothal. With intravenous anesthesia there is always the threat of aspiration from oral bleeding, and the length of operating time is definitely limited.

During recent months there has been a definite and increasing tendency to use pentothal for the induction, followed by endo-tracheal inhalation anesthesia. This removes the excitement stage of gas-ether inductions and eliminates the dangers of initiating new bleeding and aspiration.

OPERATIVE PROCEDURE

Debridement.

The patient at this time enters the operative phase. He has previously been given premedication of morphine and atropine, his shock has been controlled, his diagnosis adequately established and a satisfactory anesthetic level obtained.

Primary consideration now centers on cleaning and debridement of the wound. Many facial wounds contain only the foreign body or its fragments while others have a great deal of extreneous material driven

into the wound. The nature of this material depends upon the type of surface covering and the wounding agent. Wounds may contain metal, cloth, stone, dirt, wood and other substances. Foreign matter must be scrupulously removed either as individual fragments or by flushing the wound with large amounts of saline. Unless painstaking care is given to this feature, subsequent procedures may be rendered useless as infection from retained foreign material will usually result. Due to their tissue tolerance fine metallic particles need not be searched for.

After thorough cleansing, the process of debridement may be initiated and it is here that individual opinions differ. Debridement of the bone should be limited strictly to those fragments that will come free with the gloved finger or which may be withdrawn by wiping with gauze. If this course is followed, only those fragments having some periosteal attachment will remain. These act as potential grafts and should remain viable even though the wound communicates with the buccal cavity.

Tissue debridement is far more limited in facial wounds than elsewhere. It may be stated that buccal mucosa should not be debrided at all. Muscle tags and shreds of fascia had best be excised but only in case of the complete absence of a satisfactory attachment. In practically no case may we debride the skin more than one-sixteenth of an inch. This means a mere freshening of the margins and ragged edges in order to enhance primary union. The major point of this super-conservatism is preservation of all facial tissue. A loss of more than 5 mm. of skin adjacent to any facial orfice may well mean a severe facial deformity with subsequent multiple plastic procedures necessary for correction.

If this type of conservation of bone and soft tissue is to be a success and accomplish its purpose, it must be followed by a meticulous primary closure.

Primary Closure.

After stabilization of the bony framework, which will be discussed under fracture treatment, the tissue closure should begin with the buccal mucosa. It need not be closed tightly or too accurately for it is planned to use this buccal surface for intra-oral drainage. The areas between mucosal sutures present an extensive drainage system that will do much toward controlling the postoperative edema and induration that attend most facial wounds.

The accurate apposition of muscle and skin follows. Deep or buried sutures should be limited to as few as is compatible with approximation. The skin is best closed with multiple fine interrupted silk or dermal sutures. By proper suturing, undermining of tissue, and the utilization of local flaps all wounds may be closed primarily. These maneuvers will cover all exposed bone, protect the tissue from infection and contraction, and promote early and complete primary healing.

Many cases have been so badly contaminated with foreign material that it is imperative to drain the wound. This may be accomplished by utilizing the buccal surface rather than the skin. Inasmuch as the patient will be in the prone position drainage from most of the buccal area will be dependent. External drains are to be avoided if at all possible due to their conspicuous tendency to form sinus tracts and scar bands.

Stabilization of the fractures and closure of the soft tissue having been completed, it remains but to apply a dressing. Considerable importance is attached to this feature inasmuch as moderate continued pressure is deemed a requirement. Immobilization of the soft tissue is physiologically correct and can be adequately obtained by the use of diagonally cut stockinette bandage. This material follows the contour of the face in an excellent manner and produces a mild constant pressure.

Dressings should not be changed sooner than four or five days provided hemorrhage, acute infection, wound disruption or some other serious complication do not intervene.

Chemotherapy.

Postoperatively the patient is started on a course of 25,000 units of penicillin every four hours for a period of three days, or longer if he is febrile. Following the cessation of penicillin a regime of sulfadiazene is instituted and carried on until the soft tissues have healed or some contraindication has arisen.

Occasionally, localized cellulitis, induration and abscess formation occurred in spite of the prolonged administration of the above medicaments. This leads us to believe that their routine administration is unnecessary and probably detrimental after a fall in temperature to near normal.

Nutrition.

The more severe mandibular and maxillar cases may require some form of tube feeding for the first 48 hours, however in no case was it found necessary to continue this type of administration longer than the

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above time. This was due largely to the excellence of the nursing care and the fine cooperation of the patients. Oral intake was started on the third postoperative day and in practically all cases it was suplemented by intravenous fluids, whole blood, and plasma as indicated.

Evacuation.

The average hospitalization period for maxillo-facial cases in Evacuation Hospitals was five days and in no case did the time exceed 10 days. Some cases required longer periods due to their associated injuries.

TREATMENT OF FRACTURES

Emergency Care.

Adequate first aid treatment of the severe maxillo-facial casualty cannot be overstressed. Wounds of the face neck and jaws are, as a rule, so extensive in nature and involve such vital structures relative to respiration that prompt and correct first aid must be rendered if the casualty is to survive.

Pain is not necessarily severe in most cases, but the sensation of extreme discomfort and impending death is always present. Many times this feeling of impending death is interpreted by the medical officer or first aid man as pain. The casualty is given massive doses of morphine with the idea of relieving him of intense pain. This can be a very dangerous procedure. Any drug which tends to relax or relieve the life struggle of the casualty to maintain an adequate airway and to keep the mouth and throat clear of blood and mucus is contraindicated. Morphine can and should be used but only in minimal doses. The patient must maintain consciousness as it is only by his own efforts that the upper respiratory passages can be kept clear.

Hemorrhage must be controlled at once. Due to the size and number of vessels found in the face and neck massive hemorrhage is present in most cases. Compression type bandages or packs may be used to control the bleeding. The application of digital pressure to known points and ligation of vessels is permitted when indicated.

Experience has shown that the Barton bandage as a means of first aid dressing for maxillo-facial casualties is not adequate, and in many cases has proven to be detrimental to the well-being of the patient.

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As has been stated before, the maintenance of an adequate airway is of prime importance in all wounds of the face and jaws. A bandage which in any way burdens or makes respiration more difficult should not be used. The way in which a Barton bandage is applied with its circular tension from the chin to the occiput violates the principle of maintainance of adequate airway. The bandage has a tendency to gather the tissue within its "chin lock" and by means of its posterior wrapping to force the tissue into the mouth and cause interference with respiration. The whole principle of the Barton bandage is wrong as a first aid dressing for these cases. A bandage must be used which will act as a cradle for the injured tissue, give it support and lift it forward, upward and away from the throat and respiratory passages.

The tongue, with its tendency to drop backward into the throat in case of fracture of the hyoid and damage to the supra hyoid muscles, always presents a problem to the battalion surgeon. If the patient has no control of the tongue or if he is unconscious a suture should be passed through the tongue and tied or pinned to the clothing or bandage. Tension applied to the suture will pull the tongue forward and clear the oro-pharynx.

Transportation of the casualty will present no problem if the patient is conscious since he will assume the position best suited to his needs. Generally, this position is on the side. In the unconscious patient it will be necessary to provide for dependent drainage and a clear respiratory tract which again are best obtained by the side or face down position. The former is advocated.

Classification of Fractures.

For this paper, war fractures have been divided into two groups, using as a basis for division the simplicity or complexity of the treatment involved. As all war fractures are compound and in the majority of the cases comminuted, the accepted classification was found impractical for discussion and charting purposes. The two types of fractures used for a basic discussion hereafter are designated as uncomplicated and complicated.

The uncomplicated fracture is classified as one in which a minimum amount of treatment is required to give an adequate result and in which there are few problems to deal with at the time of initial surgery. In this type, the soft tissue wound may be more severe than the fracture but all treatment is routinely simple. The complicated fracture may be stated to be more severe, to present multiple problems in immobilization, occlusion, drainage and general treatment. The time element of surgery for the complicated fracture is greatly increased over that for uncomplicated fracture cases.

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Treatment of Fractures.

The treatment of uncomplicated fractures is not difficult. All the basic fundamental principles of civilian practice are used and are acceptable. Intermaxillary wiring has proven to be more practicable and simpler than any other means of stabilization. Stout's continuous loop method was most frequently employed. Single loop wiring may be indicated in those cases presenting an extensive loss of bone or where only one or two teeth remain in the posterior segment. Intramaxillary elastic traction has proven successful because of its ease of application and ready removability in case of emergency. Fixed wiring may be used on a floating posterior fragment where elastic stabilization may be difficult to apply and maintain.

Chin traction has frequently been used as an accessory support. The traction or chin strap is made from orthopedic elastic bandage with plasma tubing attached to an operating cap to supply the traction. It is of definite aid to the patient in that it supports the chin and tends to relax the muscle of mastication. As in civilian life, all war fractures of the simple type receive reduction whenever possible, and stabilization by means of intermaxillary wiring, intermaxillary traction, and chin support.

The treatment of compound war fractures requires all the ingenuity, skill, and surgical judgment of the maxillo-facial team. Each case is different and presents different problems although a few basic principles determined from experience apply in all cases.

One of the first and possibly most important steps in handling a case of this nature is to make a complete and thorough evaluation of the case. This must be highly stressed for it is of prime importance.

Evaluation of the case should include not only the maxillo-facial injury but the associated injuries as well. It may be imperative to do only a partial reduction of the fractures or the type of stabilization may have to be altered to reduce the time element. Decision as to gener or local anesthesia may be determined at this time. It has been found i the majority of cases that the entering wound can be closed without anes thesia or at least under local. Even under the best of conditions and in the hands of a skilled operator a minimum of one-half hour is require to place the intermaxillary wiring and in case of a badly compounded fracture the time may be greatly increased. If this work can be done without anesthesia the total operating time is reduced to a minimum and the dental officer becomes available for help in the subsequent operati procedures which will be done under general anesthesia.

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Fractures of the Middle Third of the Face.

Fractures of the middle third of the face are either the result of severe blows directly upon the involved bony framework or, in the greater number of cases the result of foreign bodies entering the face at high speed. These two classes may be grouped together and subdivided into simple and compound fractures.

Simple fractures or those resulting from the mass application of pressure are frequently depressed. The objective findings indicate the procedure of treatment. Of most common occurrence are fractures of the nose with or without displacement. If the nose is without obvious deformity it is unnecessary to treat the fracture with other than routine hygiene and the use of a vaso-constrictor to the nasal mucosa to improve the airway.

Fractures with deviation as a result of breaking the continuity of the nasal bones or frontal processes of the maxilla must be corrected by complete mobilization of the fragments before reduction is attempted. This can only be adequately done under general anesthesia. Fragments are freed by nasal forceps after which the nasal dorsum is forcibly elevated to permit the septum to be returned to its proper relationship. This maneuver prevents the septal deflection so often complicating nasal fractures. If the nasal fracture is properly reduced no splinting is necessary. Frequently the manipulation produces marked nasal hemorrhage. This is easily controlled by vaseline nasal packs for a period of 24 hours.

Compound nasal fractures and those resulting from penetration by missiles should receive a thorough cleansing and an extremely conservative debridement. Free fragments of bone should always be removed even at the expense of some deformity, for these fragments are generally lost as a result of absorption or low grade infection. Reduction of the remaining fragments is accomplished as in the case of simple fractures and adequate splinting is obtained by nasal packs.

In severe nasal wounds it is imperative that the lining mucosa of the nasal airways be approximated by suturing. The nasal airways must be maintained and if the mucosa is severely lacerated it may be necessary to suture the fragments over a catheter. Failure to do this may result in ulceration, ultimate loss of mucosa, severe scar formation and final retraction of the nasal tissue. These deformities and complications are extremely difficult and sometimes impossible to correct. Atrasia of the nasal airway may readily result from inadequate primary definitive surgery.

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If the bony framework has been adequately mobilized and reduced and the nasal lining and superficial covering accurately closed, it is probable that no splinting will be required.

Tissue loss of the dorsum of the nose, sides, and alae as well as the tip should be repaired in some form of plastic procedure. In general, losses of dorsum and lateral walls may be replaced by naso-labial flaps. This method is equally applicable for losses of the alar skin and adjacent tissue. Loss of tissue of the tip and coluella require more technical procedures for esthetic repair and hence should be closed primarily by approximating skin and mucosa in order to facilitate later surgery. If the wound is too large to permit this to be done it is best to cover the area with a Thiersch graft as a temporary procedure to prevent infection and contraction until the patient may be in a position to receive prolonge plastic surgery.

Fractures of the Zygomatic Arch and Antrum.

Simple fractures of the malar arch may result from frontal or latera blows and as a rule are depressed. Clinical appearance is that of a depression in the prominence of the cheek with a fullness at the level of the antrum. The fracture sites are generally at the suture lines and as such may involve the floor of the orbit. Diplopia is a characteristic sign resulting from the lowering of the floor of the orbit or due to interference with the function of the ocular muscles.

Reduction of the fracture and correction of the deformity is best accomplished by the Gillies method. An elevator is inserted through a skin incision over the temporal muscle and passed along the deep fascia beneath the muscle to extend beneath the depressed fragments. Moderate leverage will easily effect a dissolution of the impaction, and reduction may be readily effected. Very slight muscle pull in this area will make splinting unnecessary if adequate reduction has been accomplished.

When a crushing injury has been sustained and the floor of the antr and orbit have been shattered and depressed a combination of methods may be used. In these cases the zygomatic fragments can be mobilized by the Gillies method while the more medial elements are better handled by introducing a small elevator through a buccal incision at the level of the second bicuspid tooth. This elevator passes into the antrum and easily encounters the depressed fragments of the fracture. Mild leverag of both elevators will produce a prompt reduction. Drainage through the buccal incision for at least 24 hours is recommended.

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Mandibular Fractures.

A total of 158 mandibular fractures are included in this study and represent 57% of the total facial fractures.

Mandibular war fractures are characterized by severe comminution and tremendous loss of bony tissue. A severe shattering effect is produced by the high velocity of the missile as it strikes the bone, resulting in the mandible being broken into multiple large and small fragments. There may be a loss of bony tissue of the entire body from the midline to the angle. The soft tissue of the mouth, tongue and throat may be severely traumatized, all tending to make stabilization difficult.

Under consideration here are only those cases of fracture which are the direct result of penetrating wounds and as such are not confined to the usual angle and mental areas, but may occur at any point.

Treatment of these injuries may be divided into three steps: Debridement, closure, and fixation. Of primary importance is debridement which should be attempted only under endotracheal anesthesia preferably given by way of the nasal airway. The posterior pharynx is packed off so that the danger of aspiration of blood is practically negligable.

After all bleeding has been controlled debridement is begun. Beginning with the skin surface the margins are trimmed followed by moderate excision of the damaged fascia and muscle and lastly control of the bony fragments is accomplished. It has been our policy to remove only those portions of bone that are completely free of any attachments. These attached fragments along with their periosteum should be studiously preserved for they will provide a regenerating bridge across the destroyed mandibular sections.

Teeth in the area of impact may be either shorn off at the gingival margin or may show multiple fractures. It is characteristic of these teeth to have multiple fractures so that removal has to be done in sections and all too frequently the alveolar plate must be excised to permit the exposure of the roots. With this in mind it is deemed best not to attempt extraction of teeth from small fragments or sections of the mandible. Removal may be done after the mandible has solidified and the roots partially loosened. In severely shattering injuries the entire body and symphysis of one side may be so comminuted that the fragments contain only one or two teeth. Muscle and periosteal attachments are so reduced that the section exists only by virtue of soft tissue support.

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In this type of case it is well to immobilize the large mandibular fragment on the good side and align the small fragments by tissue suturing only. If alignment and intermaxillary wiring is attempted these small incorporated fragments would be isolated due to retraction of oral tissue. These pieces of bone should be firmly attached to their new bed before any attempt is made to align and stabilize them.

Fixation of large fragments as well as the uninvolved side may be accomplished by various types of intramaxillary wiring and occlusion maintained by intramaxillary elastic traction.

The latter greatly facilitates adjustments and permits almost immediate relief in case of aspiration. Intramaxillary wiring may be used throughout the period of stabilization and treatment. In those cases of multiple wounds of the oral cavity and pharynx a cap splint may prove more valuable when repeated access to the mouth is necessary.

The external wounds in these cases are closed as in simple lacerations. The buccal mucosa is only loosely approximated and if drainage is indicated it should be orally. If the buccal wound is relatively small external drainage may be provided by a stab wound below the level of the mandible at or near the fracture site. Much has been said regarding the closure of wounds of the face that penetrate into the mouth and in the course of the penetration have involved salivary gland tissue. The majority opinion seems to favor the tight closure of both skin and buccal mucosa to the point where the buccal laceration is impervious to contamination from mouth secretions. Some surgeons do not agree with this procedu and as a consequence have closed the skin and deep tissue of the face with the purpose of promoting primary healing of the surface tissue while the buccal surface of the wound has been loosely approximated. In those wound involving salivary tissue and others requiring drainage the procedure has been to drain from the depths of the wound into the mouth rather than through the skin surface. In no instance has there been evidence of disruption due to drainage of salivery secretions. Conversely, lacerating wounds of the parotid gland not communicating with the oral cavity invariably drain externally until such time as reduction of edema and swelling permit normal ductal drainage of the secretions.

Fractures involving partial or complete loss of the symphysis present no problem other than that offered by the tongue and the musculature of the floor in the mouth. Intramaxillary wiring of the body of the mandible provides adequate immobilization and accurate occlusion.

In this series only two cases were provided with splints. These patients were admitted 10 days after injury. Both had gunshot wounds of the symphysis with minimal bone loss or displacement. In no instance of mandibular fracture has it been found necessary to utilize the arch bar.

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All simple fractures were adequately handled by intramaxillary wiring. Of the compound cases only two were splinted and in no case was open reduction found necessary or advisable.

Debridement within the oral cavity should be at a minimum. No structure, tissue or fragment should be removed if there is a reasonable possibility of its retaining its vitality. The ability of the mucous membrane to retain its viability is remarkable, and, mucosa will often survive even though stripped from its bed and severely traumatized. Fragments of exposed bone if covered will in many cases retain their blood supply and will aid greatly in future reconstructive procedures.

As stated before complete reduction may not always be accomplished at the time of initial surgery, for the degree of reduction will depend upon the condition of the patient, associated injuries, etc.

Stabilization must be obtained in all cases eventually. Intramaxillary wiring, chin traction, cradle type bandage can all be used when definite immobilization is necessary.

Fractures of the Maxillae.

Compound maxillary fractures constitute a smaller number of the total fractures than do the compound mandibular fractures and as a rule are more easily handled. Of the 276 cases, 61 were compound maxillae which represent 22% of the total. Of the total number of compound maxillae nine or 14% had antral involvement. This number is sufficiently large to warrant a discussion of the methods of handling maxillary fractures complicated by antral involvement.

A small penetrating wound into the antrum is not, for purposes of discussion, classified as antral involvement. Only those cases presenting a loss of the bony wall are so considered.

After debridement of the area is accomplished the antrum should be closed as completely as possible while providing for drainage into the buccal sulcus. The antrum is packed at the time of surgery with half-inch vaseline gauze which is allowed to project through the drainage point into the mouth. The pack is partially removed in 24 hours and completely removed in 48 hours. Drainage is maintained. Rigid mouth hygiene should follow.

Fractures involving the hard and soft palate with severe tissue damage or loss present a difficult problem. Marked swelling is always present and may necessitate a tracheotomy for relief of this complication.

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After an adequate airway is assured the mucosa over the fracture should be sutured and the fragments reduced by digital manipulation. These fractures are usually associated with penetrating wounds of the antra or severe fractures of the maxilla and as such are stabilized in conjunction with the adjacent fractures.

In 61 cases of maxillary fracture 6% were further complicated by the involvement of the orbital bones and 6% by the zygoma. Both of these fractures should be reduced at the time of the maxillary reduction. Since surgical intervention is generally required for these fractures, even though not compounded, it has been the policy to do all reductions under general anesthesia.

Reduction of the orbital fractures may be accomplished by the external use of a towel clip or intra-oral use of an elevator introduced through the buccal sulcus. Elevation and reduction of zygomatic fractures can be done by the extra-oral method of Gillies.

Of the total maxillae involved, 20 cases or 36% were associated with fractures of the mandible. Reference to Table II will give the fractures most commonly associated with the maxilla.

Fracture of one side of the maxilla may be reduced and stabilized by intermaxillary wiring or, if the patient is edentulous, by inserting dentures and supplying support by means of chin traction.

Transverse fractures involving the entire maxilla, with the possible involvement of the antral and ethmoid sinuses is not uncommon. These cases can be best stabilized by intermaxillary wiring after manual reduction. Care must be used to restore the nasal airways to provide drainage for the involved sinuses.

Impacted fractures of the maxilla were not encountered hence complicated apparatus for their reduction was not required; this type of case would best be handled in a General Hospital.

Statistical Review.

A review of over 2,000 records of injuries of the head and neck revealed 276 cases to have suffered bony injury, and of these, 178 were known to be the result of missile trauma. Of the 276 cases, 61 were the result of civilian type accidents or agents and in 37 cases the agent were unknown.

From statistics compiled at an Evacuation Hospital from 12 April 1944 until 2 April 1945, it was found that 4% of the 6943 battle casualti

passing through the hospital had injuries of the head and neck. Of the 4%, 104 cases or 1.7% had bony injury and can be classified as true maxillo-facial cases. This finding closely follows the Theater finding of 2.2%. The 1.7% would be increased if inclusion were made of those cases presenting extensive soft tissue injury without bony involvement.

It is of note that true severe maxillo-facial cases comprise only a small part of the total battle injuries.

A further finding is the extreme rarity of cases presenting excessive loss of facial tissue. In fact, it may be postulated that only the rare case presents an appreciable tissue loss.

Of the 276 listed cases of facial fractures 151 or 54% were the result of shell fragments. Ten cases were the result of mines and 17 were due to small arms.

Non-battle facial fractures comprise some 36% of the total. This proportion has been consistent throughout the Theater.

High velocity missiles have the characteristic of a small point of entry, marked explosive type of damage to the soft tissue, extreme comminution of bone, and a proportionally large portal of exit.

Bone is shattered at marked distances from the point of contact and fragments are widely dispersed into the surrounding tissue. Shell fragments differ from small arm missiles only in that their bulk may increase their range of tissue damage, and their motion and size produce a greater amount of trauma at their points of entry and exit.

Table I.

This table indicates the predominance of definitive treatment in the Evacuation and General Hospitals. Intermaxillary wiring has been done in 18% of the cases encountered in the Field Hospitals as against 60% in the Evacuation Hospitals and 67% in the General Hospitals.

Tracheotomies are listed as 29% in field units and 9.5% in Base Hospitals, which indicates two possible considerations. One, that those cases triaged to Field Hospitals are more severe and two, that definitive surgery in Evacuation and General Hospitals will often eliminate the necessity for tracheotomy.

Table II.

If facial fractures are grouped as to severity it is found that approximately one-third are severe, one-third moderate, and the remaining third mild. If the grouping is limited to battle casualties only, the

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy. (Treatment of Fractures, contd).

percentage of severe cases is increased 55% due to the compounding of the fracture.

It is of interest to note that only 35 were not associated with other injuries. Of the 35 cases 30 were civilian type injuries.

Of the associated soft tissue injuries the face was involved in 198 cases, this involvement being limited to forehead, cheeks and chin. Involvement of the lips, nose, tongue and eyes were next in frequency and occurred in the order given.

In the [illegible] compound fractures of the mandible the tongue was involved [illegible] times.

TABLE I

Definitive Treatment of Fractures of Mandible and Maxilla Relative to Hospitals

Treatment	Field Hospital No. Cases	Field Hospital Percent of 65 Cases Treated	Evacuation Hospital No. Cases	Evacuation Hospital Percent of 112 Cases Treated	General Hospital No. Cases	General Hospital Percent of 29 Cases Treated
Intermaxillary Wiring	12	18.%	70	60.%	20	67.%
Primary Closure	35	53.%	85	73.%	9	30.%
Dressings	29	44.%	22	19.%	2	5.6%
Preoperative Fluid Therapy	21	32.%	25	21.%	1	2.8%
Emergency Extension Support	5	.7%	1	.1%		
Tracheotomy	19	29.%	11	9.5%	3	10.3%
Acrylic Splint			1	.17%	1	2.8%
Simple Reduction	6	.9%	11	9.5%	6	20.6%
Chin Traction	1	.1%			3	10.3%
No Record of Treatment	4	6.%	6	5.2%	1	2.8%

Total Cases Seen by Field Hospital - 65
Total Cases Seen by Evacuation Hospital - 112
Total Cases Seen by General and Station Hospitals - 29

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy.

TABLE II

Severity of Fractures

	Mandible	Maxilla	Mandible & Maxilla	Others
Severe	67	26	16	44
Moderate	49	16	9	97
Slight	41	18	1	30

Complicating and Associated Injuries

Associated Injuries:

Extremities	98
Chest	28
Abdomen	14
7th Nerve Laceration	3
Brain	13
Neck	44

Complicating Injuries:

Tongue	27
Lips	38
Face	198
Septum	4
Nose	37
Eyes	10

TABLE III

Missile Type	Total	Percent of 276 Cases
Shell	151	54.%
Mine	10	3.6%
Bullet	17	6.1%
Civilian Type		
Car	23	8.3%
Blow	36	12.6%
Fall	1	.36%
Plane	1	.36%
Unknown	37	13.7%

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy.

TABLE IV

Relation of Fracture to Agent

	Mine	Shell	G.S.W	Trauma	Car	Unknown	Total
S. Mandible	0	3	0	7	8	2	20
C.C. Mandible	3	97	14	5	3	16	138
S. Maxilla	0	5	0	1	3	1	10
C.C. Maxilla	2	36	5	1	1	6	51
Antra	5	21	3	2	0	6	37
Nasal	2	19	1	18	13	10	63
Frontal	1	7	1	3	0	4	16
Zygoma	1	15	2	9	8	3	38
Condyle	0	2	0	1	3	2	8
Hyoid	0	4	0	0	0	0	4
Coronoid	0	2	0	1	0	0	3
TOTAL Individual Fractures							388

Tables III and IV.

High explosive shell fragments accounted for 54% of all fractures and 85% of all casualties in this series. Small arms fire accounted for but 9% and mines 5% of all fracture cases. It is to be noted that 35% of all facial fractures are the result of civilian type accidents and as such must be classed as pptentially avoidable accidents.

Tables V, VI, and VII.

These tables indicate the relative frequency of the various fractures and their associated fractures.

Due to their size and prominence the mandible and maxilla lead in frequency, and the combination of the two fractures occurs approximately five times more often than any other.

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy.

TABLE V

Multiplicity of Fractures Involving Mandible

	No. Cases	Percent of Total Mandibles	Percent of Total Facial Fractures.
S. Mandible	13	8.2%	3.3%
C.C. Mandible	102	64.0%	26.0%
S. Mandible - Zygoma	4	2.5%	0.13%
C.C. Mandible - Condyle	1	0.63%	0.2%
C.C. Mandible - C.C. Maxilla	20	12.0%	5.4%
C.C. Mandible - C.C. Maxilla Antral - Frontal - Nasal	4	2.5%	1.03%
C.C. Mandible - Antral	6	3.8%	1.5%
C.C. Mandible - Orbital - Zygoma	1	0.63%	0.2%
C.C. Mandible-Hyoid	2	1.5%	0.4%
C.C. Mandible - Zygoma	4	2.5%	1.03%
TOTAL Mandibles Involved 157			
TOTAL Fracture Cases 388			

TABLE VI

	No. Cases	Percent Total of Cases	Percent Total of Fractures
S. Maxilla	2	3.6%	1.51%
C.C. Maxilla	8	14.0%	2.06%
C.C. Maxilla - C.C. Mandible	20	36.0%	5.15%
C.C. Maxilla - C.C. Mandible Frontal - Nasal [8]	4	7.2%	1.03%
S. Maxilla - Antral - Nasal	1	1.9%	0.25%
S. Maxilla - Nasal	5	9.0%	1.2%
S. Maxilla - Zygoma	2	3.6%	0.51%
C.C. Maxilla - Nasal	5	9.0%	1.2%
C.C. Maxilla - Zygoma	4	7.2%	1.03%
C.C. Maxilla - Antral	4	7.2%	1.03%
TOTAL Maxillae Involved 55			
TOTAL Fracture Cases 388			

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy.

TABLE VII

Multiplicity of Fractures - Mixed

		No. Cases	Percent of Mixed Cases	Percent of Total Fracture Cases
Nasal		37	43.0%	9.5%
Nasal - Antral		3	3.3%	.8%
Nasal - Frontal		2	2.2%	.5%
Nasal - Zygoma		2	2.2%	.5%
Antral - Frontal		3	3.3%	.8%
Antral		7	7.7%	1.8%
Antral - Zygoma		2	2.2%	.5%
Frontal - Zygoma		1	1.1%	.25%
Frontal		6	6.6%	1.5%
Zygoma		19	21.0%	4.8%
Condyle		4	4.4%	1.03%
Coronoid		1	1.1%	.25%
Hyoid		2	2.2%	.5%
TOTAL Destruction		1	1.1%	.25%
TOTAL Mixed Facial Cases	90			
TOTAL Fracture Cases	388			

Maxillo-Facial Deaths.

Figures taken from a survey of 1165 deaths recorded in forward hospital installations show a 0.6% mortality rate for maxillo-facial cases. Of the eight cases recorded six were due to maxillo-facial injury and two had minor associated injuries.

Of the six maxillo-facial cases one death was the result of encephalomalacia following ligation of the common carotid artery, three died from shock and two from associated brain injuries.

SUMMARY

1. A study was made of 276 patients with fractures of the facial bones.

2. The use of sulfonamides, penicillin, and blood replacement therapy permits primary closure of the soft tissue wound with a reduction in infection and deformity.

3. While the degree of shock was minimal in most cases (an average of only 125 c.c. of blood plus 100 c.c. of plasma being required), severe

Study of 276 Cases of Facial Fractures Treated in Field, Evacuation, and General Hospitals in Italy. (Summary, contd).

blood loss occasionally required repeated transfusions.

4. Interdental wiring with intermaxillary elastic traction is applicable to nearly all of these cases, fulfills nearly all requirements of fixation, and may well constitute the definitive as well as the primary treatment.

5. Of the 276 cases, 178 were due to missile trauma.

6. Statistical tables are presented, covering etiology, methods of treatment, severity, complications, type and distribution of the injuries.

MAXILLO-FACIAL INJURIES

PART II

IN THE BASE HOSPITALS

BASE SECTION MAXILLO-FACIAL CARE

INTRODUCTION

The mental image suggested by the term "gunshot wound of the face and jaws" invariably induces an emotion of sympathy, pity, or out and out revulsion. While numbering few in the total of war casualties, they demand and deserve every conceivable effort in the matter of medical care. This implies skills and facilities over and above the level of "proper" or "ordinary" care, providing it is consistent with the best interests of the Military Service to provide them.

An opportunity was afforded for one team from the 2nd Auxiliary Surgical Group to serve in a Maxillo-Facial Center at the 52nd Station Hospital in Naples, Italy, for 10½ months, from May 1944 to April 1945, or all but two months of the period of activity of the center. This project was unique in that the paucity of such injuries had not seemed to warrant a full scale effort, complete with triage arrangements, prior to the period of April 1944. Hence, it was felt by the Theater Surgeon that it would be preferable to set limited goals well within reach of attainment rather than to prejudice the chances for success by setting out on too ambitious a program. Experience has shown this to have been a wise decision.

The goals toward which effort was spent were as follows:

1. To return the man to duty in the Theater.

2. To prevent deformity.

3. To gather all possible facts and data regarding this type of casualty.

Significantly omitted is the effort to <u>correct</u> deformity where it was evident the man could not be returned to duty in 90 or 120 days in this Theater. The prognosis as to this factor was often extremely difficult at the time of admission, for tissues heal differently in each patient. However, after a few weeks' hospitalization it was usually possible to classify each case nicely so that reconstructive efforts might be limited to those which would return to duty, and the others prepared for return to the United States for further treatment.

STATISTICAL STUDY

Seven hundred ninety patients were registered on the Maxillo-Facial Service during the 11 months it was operative. The records of these

patients were studied in three groups, some of which were overlapping, but it seemed the best composite picture of the statistical data could be presented in that way. This study was made by three individuals, one to each group: Lt. Col. Langdon Parsons, Major H. B. Clark, Jr., and Major Walter Bird. The findings and conclusions are possibly somewhat colored by the feelings of the man surveying each group, but by and large the opinions met with unanimous agreement.

CASES WITH FACIAL SOFT TISSUE WOUNDS ONLY

Two hundred thirty-five soft part wounds without facial fracture were studied. The mean average time from injury to arrival at the Center was four days.

The mean average time from injury to first definitive treatment was eight hours.

Seventy-eight percent of the entire 235 returned to duty in this Theater.

Sixty-five percent of the 235 or 155 were primarily sutured. Of these, 66% were sutured in the first 12 hours.

Seventy-nine percent of the patients primarily sutured returned to duty.

Eighty percent in this group were classified as moderate or severe, while only 50% of those debrided with or without suture appeared in this category.

The multiplicity of wounds other than to the face prolonged the hospitalization and decreased the number returning to duty appreciably.

Excluding associated wounds to other structures only 3% returned to the Zone of Interior.

CONCLUSIONS

Primary suture of the face may well be employed as a standard procedure without fear of sepsis. The possibilities of a scar deformity will be reduced to a minimum. This is important for the individual, for the Army, and for the national exchequer. Where the wound involves the

face alone and is not complicated by associated damage to other structures the man may well be returned to duty within the Theater.

Without increasing the risk to the patient, primary suture will in a facial wound of equal severity return a higher percentage of men to duty, with a better cosmetic result, in a shorter period of time, than any other of the popular surgical procedures. It is suggested that it be adopted as a standard approach to this type of wound.

CASES WITH SOFT TISSUE WOUNDS OVER FACIAL FRACTURES

Primary suture over compound wounds of the facial bones was successfully accomplished in 182 cases among 270 missile wounds, or 70%.

Eighty percent of the primarily sutured cases were classified as severe, as against 64% for those debrided only.

Three percent of the original primary sutures subsequently broke down.

Osteomyelitis was present in 3% of those primarily sutured as against 5.5% for the entire group. Two cases developed non-union of fracture.

Seventy percent of the 182 cases were sutured after six hours and 40% after 12 hours.

Sepsis of all degrees among the group of 270 was present in 29%. Twelve percent were regarded as severe, with profuse purulent discharge. The end result was influenced by the sepsis in only 2%.

The difficulties of suture over compound fractures in the region of continual contamination are obvious, but the possibility of improving tremendously the patient's status makes the effort worthwhile. These closures should invariably be drained for 48 hours.

CONCLUSIONS

A noteworthy observation at this Center was the fact that virtually none of the hideous, wide-open facial wounds of World War I fame were seen. The basic reason for this lies in the primary closure of the wound

following a meticulous debridement. Preferably this should be accomplished within the first 12 hours. Yet 40% were done after that time without increasing the amount of sepsis. The important factor is the meticulous debridement, not the time interval.

After seeing all varieties of primary closure as well as a large number where debridement alone has been performed, we are convinced that disfigurement and deformity can be prevented to a large extent by this procedure.

In brief, it would be ideal to care for both soft tissue damage and bony displacement at the same time and within a few hours of wounding. Yet this is not always possible. While we agree that early reduction and fixation of the facial fracture is highly desirable it is our feeling that if only a certain amount of time and energy are available for any given case, the first attention should be directed toward the soft part damage. This point will be further discussed in the sections on treatment of the fracture.

CASES WITH FRACTURE OF THE MAXILLA

One hundred fifty cases with fracture of the maxilla, with or without other facial fracture, were studied. Among the various combinations of injuries, 25% had fracture of the maxilla alone, 22% had fracture of maxilla and mandible, and 14% had fracture of maxilla and malar bones.

Eighty-five percent battle casualties and 15% civilian type injuries are noted.

Civilian type injuries are less severe - twice as many men return to duty.

The extent of comminution in this group is severe, being rated as "severe" in 45% and "moderate" in 25%.

Bone loss and displacement are less frequent than in the lower facial area. (A possible explanation for this finding is that when such wounds occur in the upper face the injury is quite likely to prove fatal and do not reach the hospital).

The extent of compounding has a direct bearing on disposition, i.e., a case compounded both through skin and oral mucosa is less likely to return to duty than one compounded through either surface singly.

Base Section Maxillo-Facial Care. (Cases With Fractures of the Maxilla, contd).

Observations on patients received from forward hospitals showed that proper care had been carried out in nearly all instances. However, 45% of the cases in this group requiring interdental wiring had not had it done prior to admission to this Center. The time delay apparently did not jeopardize their chance for a prompt recovery. Thirty-eight percent of this group returned to duty in this Theater. One and three tenths percent of this group died after admission at the Center.

CONCLUSIONS

The general impression is gathered as far as returning a man to duty with an upper facial fracture is concerned, that the ultimate disposition is determined from the moment he is hit on the field of battle. This is chiefly so because of the high incidence of crippling associated injuries. Further, salvage is possible by early attention to the soft part injury even at the expense of some delay in meticulous reduction of the fracture. Some doubtful cases would be returned to duty with a more elastic evacuation policy.

CASES WITH FRACTURE OF MALAR BONE ALONE AND NASAL BONES ALONE

Small groups of 21 solitary malar fractures and 16 solitary nasal fractures were studied. All other injuries to these bones were grouped in the series above.

Prompt reduction of the displacement is imperative if deformity is to be avoided. After 14 days it may be assumed the fracture will be fixed, so that refracturing measures will be required.

These fractures must be diligently sought for in all upper facial injuries with edema, for the swelling may well remain for the 14 day period.

CASES WITH FRACTURE OF THE MANDIBLE ALONE

Of 219 fractures of the mandible alone, 73% were missile type of injuries and 26% were of the so-called civilian type.

Two cases of non-union were present among 58 civilian type injuries.

Base Section Maxillo-Facial Care. (Cases With Fracture of the Mandible Alone, contd).

Eighty-five percent of the civilian type injuries returned to duty as against 40% for the missile type injuries.

In the entire group 70% were unilateral fractures - 66% in the body of the mandible.

Comminution was present in every missile type injury and in 70% of the entire group.

Seventy percent of comminution had more than two cm. of mandible involved.

Bone loss was present in 30% of cases.

Eighty percent of compounding occurred through the skin or skin and mucous membrane. Seventy percent of the entire group were compounded to a severe degree.

Interdental witing and intermaxillary elastics were the most popular methods of treatment. Less than 20% required any basic alteration.

Trismus has more relation to extent of comminution and compounding than to duration of fixation.

The upriding fragment and displacement at the symphysis together with bone and soft tissue loss present the greatest problems.

Displacement of the condyle is rarely troublesome.

Thirty-five cases of tooth in-line-of-fracture without other mechanism of compounding were available. Delayed union was noted in one and soft part sepsis requiring drainage in three.

CONCLUSIONS

The relative importance of the soft part wound in relation to the treatment of the fractured mandible is well demonstrated by the differenc in the number of patients returning to duty following the so-called civil type of injury, as compared to the missile, or battle types of injury. The civilian type of injury returned to duty twice as frequently as the missile type. Though the degree of compounding is greater in the missile type, the main difference lies in the extent of the soft part damage.

The method of treating these cases by interdental wiring with intermaxillary elastics or wire for the usual type of case has demonstrated its efficiency to a marked degree and certainly may be regarded as the treatment of choice for the Army patient. It can be applied at the first treatment and in many instances respresents the sole definitive treatment. The fact that less than 20% required any basic alteration is ample proof of this fact.

There still remain the basic problems of the disintegrated symphysis with bone and soft tissue loss, the upriding proximal fragment, the missing teeth, and the edentulous patient. It is in this group that arch bars, acrylic or silver cast splints are most useful. The other problems of trismus, tooth-in-line-of-fracture, the displaced condylar head, and the collapsed lateral segment proved to be far less common in occurrence than would have been expected.

From the point of view of salvage in this group perhaps a more optimistic attitude toward early operative interference with bone replacement might well be considered.

There will always be the case where soft part and bone loss is so extensive that closure of the soft parts at the expense of the fracture may be questionable. It is nevertheless a debatable point, for certainly a soft tissue bed fibrosed by prolonged sepsis is not a proper field for reconstructive surgery. Assuming that there are cases which should have fixation of the fracture to the neglect of the soft part wound, it still holds from this experience that these cases are so infrequently encountered that they should not be permitted to sabotage the entire program of early soft part closure as the primary consideration.

RETAINED FOREIGN BODIES

On the subject of foreign bodies, in connection with gunshot wounds of the face and jaws, it was concluded that they may be retained with a minimum of symptoms. Special indications for removal from strategic areas must be based on surgical judgment. In forward areas they should usually not be removed unless readily available during the course of the debridement.

DISEASE CONDITIONS OF MAXILLO-FACIAL AREA

During the course of its operation 52 patients entered the Center with various disease entities. The most frequent diagnosis was cellulitis, with 22 cases. Others were, in the order of frequency: mandibular

Base Section Maxillo-Facial Care. (Disease Conditions of Maxillo-Facial Area, contd).

joint disorder, maxillary sinusitis, osteomyelitis of mandible, tumor, and sebaceous cyst. Of this group, 48 were returned to duty and four sent to the Zone of Interior.

EYE INJURIES

Ninety-eight eye cases were studied as a separate group, of which 58 were not recorded in the list of 790 maxillo-facial cases.

Perforating wounds or rupture of the globe resulted in enucleation in 44%.

Intra-ocular hemorrhage occurred in 16 cases, invariably associated with severe reduction in vision or blindness.

Figures on intra-ocular foreign bodies were unsatisfactory as many eyes, which doubtless contained metal, had been removed at forward installations.

Mine fragments ranked high among etiological agents for eye injuries.

DISPOSITION

Overall disposition of the 790 patients was as follows:

	To Duty	To Z. of I.
Battle Casualties	349	235
Civilian Type	183	23
TOTALS	532 or 67%	258 or 33%

9. VASCULAR INJURIES

ARTERIAL INJURIES IN WAR WOUNDS

SECTION A - SUMMARIZING TABLES OF DATA ON ARTERIAL INJURIES

SECTION B - DETAILED DATA ON ARTERIAL INJURIES

SECTION C - DETAILED CASE CHARTS

ARTERIAL INJURIES IN WAR WOUNDS

Many major vascular injuries were found in seriously wounded patients treated in the high priority hospitals of the Mediterranean and European Theaters during the war just ended. Injuries of certain major arteries operated upon by surgeons of the 2nd Auxiliary Surgical Group in these hospitals form the basis for this report.

Four hundred sixty-three injuries to major arteries in which an attempt had been made to preserve the involved limb were tabulated. These occurred in 458 patients. Since our chief interest lay in the relationship of arterial injury to viability of limbs, the vessels studied were the major arteries of the extremities and the branches of the aorta which supply them. Injuries to other major arteries, either visceral or parietal, within the trunk, for example the hypogastrics, were not tabulated because they bore no direct relationship to limb survival.

Separate tabulations were made of a group of 182 "primary amputations" in 180 patients (in addition to and separate from the 463 arterial injuries referred to above). For purposes of this study, we listed only those primary amputations in which the surgeon had noted that the lack of blood supply was the chief, or one of the most, important reasons for doing the amputation primarily.

These "primary amputations" are included in this presentation because their number, added to the 463 arterial injuries in which the limb was preserved initially, will represent a fairly complete estimation of the total arterial injuries.

The injuries to the carotid arteries (17 injuries in 17 patients) and a single instance of injury to the innominate artery have been tabulated separately from the arteries concerned with the blood supply of the extremities.

Acute arteriovenous fistulae (5) and acute aneurysms (2) encountered in the forward hospitals also have received separate listing. These vessel wounds have been recorded primarily under the particular artery involved and this additional listing is merely for purposes of separate analysis.

In general, the surgeons of this Group followed a radical policy toward arterial injuries whether diagnosed preoperatively or at the time of wound debridement. This policy was careful surgical investigation of any wound when it was felt that either the blood supply to the extremity was jeopardized or the local findings of hemorrhage made surgery imperative.

Several factors limited both the scope and the accuracy of this study: (1) Evacuation of patients. Patients with doubtful circulation in an extremity were held in forward hospitals until a favorable result was assured or amputation performed. The tactical situation, however,.

Arterial Injuries in War Wounds (contd)

occasionally required the premature evacuation of some such cases or even the entire hospital. Deleterious effects on life and limb of some patients may have resulted. (b) Records. Some of the clinical records were incomplete particularly in respect to the fate of the limb or of the patient while still in the forward hospital after operation. Because of these deficiencies a few cases could not be tabulated at all, and in certain of our tables other cases had to be marked as "undetermined".
(c) Follow-up. Progress notes after evacuation have been obtained on only a small portion of these patients. The data presented in this study, therefore, are in the main only those recorded during the periods of treatment and observation in the forward hospitals.

The material for this study is presented in three sections. Section A consists of tables summarizing the distribution of injuries, percentage of limb loss, relation of time lag and fractures to limb loss, and mortality statistics. Section B contains detailed data on certain individual arteries, including the effects of various types of lesions on limb loss and detailed tables on treatment. Section C consists of detailed case charts on carotid artery injuries, acute aneurysms and acute arteriovenous fistulae.

In many of the charts it will be noted that percentages for limb loss and mortality for certain arterial injuries are at variance with the Group's experience and common sense. This is due to two factors. First, percentages for the above factors in a small group of injuries result in greatly disproportionate statistics. The fallacy of percentages of small numbers is readily apparent (Note amputation rate for the anterior tibial artery) and needs no further comment. Second, although deaths and amputations usually were recorded by the surgeon we did not consider all the other patients and limbs as having survived. Only those having postoperative notes, or at least a note relative to evacuation, were considered as having survived.

Section "A"

TABLE I

Distribution of 480* Injuries of Major Arteries

Brachial	99	Axillary	25	Superficial and deep femoral	6
Popliteal	72	Radial	20	Subclavian	4
Superficial femoral	67	Common Carotid**	17	Radial and ulnar	4
Posterior tibial	57	Common femoral	14	Common iliac	4
Anterior tibial	36	Ulnar	12	Innominate	1
Anterior and posterior tibial	30	External iliac	12		

* Included above with the artery involved are 4 acute arteriovenous fistulae and 2 acute aneurysms. Not included in the above total is one case of an arteriovenous fistula between an external carotid and an internal jugular vein.

** One case of injury to both the internal and the external carotid arteries is listed and charted as a common carotid artery.

The order of frequency of arterial injuries also may be considered from the standpoint of true numbers of injuries to closely associated arteries. Thus, instead of the brachial artery with 99 injuries being first, the tibials (anterior, posterior and the combination of anterior and posterior) with 123 injuries would be first in order. The corrected order would then be: first, tibials, 123; second, brachials, 99; third, femorals, 87; and fourth, popliteals, 72.

Table II A presents the percentage of limb loss for each artery. This represents the group for which secondary amputation was necessary following the initial operation on the vessel. The percentages of total amputations are actually higher than would be expected from mere ligation of a main artery. It would be anticipated that in a fair number of cases the branches of the main artery would act as collateral circulation. However, in war wounds with large excavating defects and extensive muscle damage of the extremities many arterial branches are injured and the blood supply is further jeopardized. Furthermore, clostridial myositis also interferes with the patency of the small blood vessels. Thus the degree of soft tissue destruction is a factor of great importance in eventual limb viability. This introduces an element which does not lend itself to statistical evaluation. In lieu of this, Table III lists the effects of compounded fracture on limb loss. Compounded fractures were usually noted in the surgeon's case reports and are used here as an index of the severity of the wound. This table shows fairly consistently the higher rate of limb loss when the arterial injury is associated with a compounded fracture.

The purpose of Table II B is an attempt to arrive at a more accurate estimation of total arterial injury by including "primary amputations" (amputation done at time of initial operation). Thus, for example, the limb loss of 68.4% for the popliteal artery (Table II A) is increased to 83.9% (Table II B). These figures are again of importance only for the arteries more frequently injured.

Arterial Injuries in War Wounds (Limb loss) (Section "A", contd)

TABLE II A

Limb Loss in Arterial Injuries with Limb Preserved at Initial Operation

Vessel	No. of Limbs*	Secondary Amputations Number	Secondary Amputations Percent
Subclavian	4	1	25.0
Axillary	19	6	31.6
Brachial	75	14	18.8
Radial & ulnar	3	1	33.3
Radial	14	1	7.0
Ulnar	10	1	10.0
Common iliac	3	1	33.3
External iliac	11	4	36.4
Common femoral	12	7	58.3
Superficial & deep femoral	4	3	75.0
Superficial femoral	52	24	46.2
Popliteal	57	39	68.4
Anterior & posterior tibial	28	10	35.7
Anterior tibial	22	18	81.8
Posterior tibial	45	4	8.9
TOTAL	359	134	37.3

* In which fate of limb is known.

Arterial Injuries in War Wounds (Limb loss, contd) (Section "A", contd)

TABLE II B

Total Limb Loss*

Vessel	No. of Injuries	Injuries Requiring Primary Amputation	Injuries Requiring Secondary Amputation	Total Amputations	Percent of Amputations
Subclavian	4	0	1	1	25.0
Axillary	24	5	6	11	45.8
Brachial	95	20	14	34	35.8
Radial & ulnar	9	6	1	7	7.8
Radial	14	0	1	1	7.1
Ulnar	10	0	1	1	10.0
Common iliac	4	1	1	2	50.0
External iliac	12	1	4	5	41.7
Common femoral	14	2	7	9	64.3
Superficial & deep femoral	14	10	3	13	92.8
Superficial femoral	73	21	24	45	61.6
Popliteal	112	55	39	94	83.9
Anterior & posterior tibial	78	50	10	60	76.9
Anterior tibial	25	3	18	21	84.0
Posterior tibial	53	8	4	12	22.6
TOTAL	541	182	134	316	58.2

* In which fate of limb is known.

Arterial Injuries on War Wounds (Associated fractures, contd)
(Section "A", contd)

TABLE III

Relation of Associated Fractures to Limb Loss in 355 Arterial Injuries

Vessel	Total Limbs	Fract or No Fract	Vessel Injuries Number	Vessel Injuries Percent	Amputations Number	Amputations Percent
Subclavian	4	Fr.	0	0.0	0	0.0
		No Fr.	4	100.0	1	25.0
Axillary	19	Fr.	7	36.8	3	42.8
		No Fr.	12	63.2	3	25.0
Brachial	75	Fr.	30	40.0	9	30.0
		No Fr.	45	60.0	5	11.1
Radial &	3	Fr.	0	0.0	0	0.0
ulnar		No Fr.	3	100.0	1	33.3
Radial	14	Fr.	9	64.3	1	11.1
		No Fr.	5	35.7	0	0.0
Ulnar	10	Fr.	5	50.0	0	0.0
		No Fr.	5	50.0	1	20.0
Common	3	Fr.	0	0.0	0	0.0
iliac		No Fr.	3	100.0	1	33.3
External	11	Fr.	0	0.0	0	0.0
iliac		No Fr.	11	100.0	4	36.4
Common	12	Fr.	3	25.0	2	66.6
femoral		No Fr.	9	75.0	5	55.5
Superficial	52	Fr.	13	25.0	9	69.3
femoral		No Fr.	39	75.0	15	38.4
Deep & super-	4	Fr.	2	50.0	2	100.0
ficial femoral		No Fr.	2	50.0	1	50.0
Popliteal	57	Fr.	31	54.4	23	74.1
		No Fr.	26	45.6	16	61.6
Anterior &	28	Fr.	20	71.4	6	30.0
posterior tibial		No Fr.	8	28.6	6	75.0
Anterior	21	Fr.	15	71.4	2	13.3
tibial		No Fr.	6	28.6	0	0.0
Posterior	42	Fr.	17	40.5	3	17.7
tibial		No Fr.	25	59.5	1	4.0
TOTAL	355					
TOTAL		Fr.	152	42.8	60	39.5
		No Fr.	203	57.2	60	29.5

Arterial Injuries in War Wounds (Time lag) (Section "A", contd)

TABLE IV

Effect of Time Lag from Wounding to Initial Surgery on Limb Loss in 300 Arterial Injuries

Time lag (hours)	0 - 6			6 - 12			12 - 18			18 - 24			24 plus		
	T*	L**	%	T	L	%	T	L	%	T	L	%	T	L	%
Subclavian	4	1	25.0												
Axillary	4	3	75.0	9	2	22.2	1			2					
Brachial	14	4	28.6	35	4	11.4	9	1	11.1	3	1	33.3	1		
Radial & ulnar	1			2	1	50.0									
Radial	3			8			1								
Ulnar	1			4											
Common iliac				1			1	1	100.0						
External iliac	4	3	75.0	5	1	20.0									
Common femoral	1			4	2	50.0	4	2	50.0	1	1	100.0	1	1	100.0
Superficial femoral	10	4	40.0	17	9	52.9	8	2	25.0	3	2	66.6	4	2	50.0
Deep and superficial femoral				4	3	75.0									
Popliteal	15	9	60.0	27	18	66.6	7	5	71.4	2	1	50.0	5	5	100.0
Anterior and posterior tibial	5	3	60.0	11	5	45.5	4	1	25.0	1	1	100.0	2		
Anterior tibial	1			7	1	14.3	4						2		
Posterior tibial	8	1	12.5	19	2	10.5	5	1	20.0	3			2		
TOTAL	71	28	39.3	153	48	31.4	43	12	27.9	16	7	43.7	17	8	47.1

* Number of arteries injured
** Number of limbs lost

TABLE V

Mortality in Injuries to Arteries in 411 Patients

	Vessel Injured Alone					Vessel Injury Complicated by Major Wound								
		Deaths					Deaths							
	No. Cases	Due to Vessel Injury	Due to General Causes	Total Deaths	Percentage of Deaths	No. Cases	Due to Vessel Injury	Due to General Causes	Due to Compl. Wounds	Total Deaths	Percentage of Deaths	Total Cases	Total Deaths	Percentage of Deaths
Subclavian	2	0	0	0	0%	2	0	1	0	1	50.0%	4	1	25.0%
Axillary	12	2	0	2	16.6%	10	1	1	0	2	20.0%	22	4	18.2%
Brachial	46	2	1	3	6.5%	31	0	6	5	11	35.5%	77	14	18.2%
Radial and Ulnar	3	0	0	0	0%	1	0	0	1	1	100.0%	4	1	25.0%
Radial	15	0	1	1	6.7%	5	0	0	0	0	0%	20	1	5.0%
Ulnar	8	1	0	1	12.5%	4	0	0	0	0	0%	12	1	8.3%
Common Iliac	1	0	0	0	0%	4	0	1	1	2	50.0%	5	2	40.0%
External Iliac	1	0	0	0	0%	11	3	1	1	5	45.4%	12	5	41.7%
Common Femoral	8	1	2	3	37.5%	4	1	0	0	1	25.0%	12	4	33.3%
Superficial Femoral	46	3	1	4	8.7%	13	3	2	0	5	37.7%	59	9	15.3%
Superficial and Deep Femoral	4	2	0	2	50.0%	1	0	0	0	0	0%	5	2	40.0%
Popliteal	38	0	1	1	2.6%	18	1	0	2	3	16.6%	56	4	7.1%
Anterior and Posterior Tibial	5	1	0	1	20.0%	25	0	1	2	3	12.0%	30	4	13.3%
Anterior Tibial	17	1	0	1	5.9%	19	0	0	0	0	0%	36	1	27.7%
Posterior Tibial	23	0	1	1	4.3%	34	0	0	0	0	0%	57	1	1.7%
TOTALS	229	13 (5.7%)	7 (3.0%)	20	8.7%	182	9 (4.9%)	13 (7.2%)	12 (6.5%)	34	18.7%	411	54	13.1%

Patients who died from the following causes were placed in the category of deaths due to vessel injury: Hemorrhage from the injured artery and the resultant shock, clostridial myositis which appeared after the initial vessel surgery, and pulmonary emboli arising from the wound area which involved the injured vessel. Deaths due to pneumonia, atelectasis or emboli not arising in the wound area involving the injured artery were classified as deaths due to general causes.

The over-all mortality for the 411 patients was 13.3%. This rate, when broken down, revealed, a mortality of 8.7% for arterial injuries uncomplicated by other major wounds, and a rate of 18.7% for those having other major complicating wounds. Mortality rates for each artery with and without major complicating wounds are indicated in the above table. In section B the tables which are repeated for mortality rates for the individual arteries list the exact causes of death when such information was available.

Arterial Injuries in War Wounds (Axillary arteries, contd) (Section B)

Section "B"

TABLE VI A

Relation of Type of Lesion to Limb Loss in 19 Injuries of the Axillary Artery

Lesion *	Number of Limbs	Amputations Fingers	Above Elbow	Total	Percent
Transection	7	2	1	3	42.9
Laceration	9	0	3	3	33.3
Spasm	2	0	0	0	0.0
Compression	1	0	0	0	0.0
TOTAL	19	2	4	6	31.6

* Three cases of Thrombosis are not included because the fate of the limb was not recorded.

TABLE VI B

Relation of Fracture to Limb Loss in 19 Injuries of the Axillary Artery

	Number of Limbs	Amputations Fingers	Above Elbow	Total	Percent
No Fracture	12	1	2	3	25.0
Compounded Comminuted Fracture	7	1	2	3	42.8
TOTAL	19	2	4	6	31.6

Arterial Injuries in War Wounds (Axillary arteries, contd) (Section "B", contd)

TABLE VI C

Results of Various Types of Treatment of 13 Injuries of the Axillary Artery as Measured by Limb Loss

Lesion	Procedure	No.of Limbs	Amputations Fingers	Amputations Above Elbow	Amputations Total
Transection and Laceration	Ligation	8	1	3	4
	Ligation & stellate ganglion block	6	1	1	2
	Suture & stellate ganglion block	1	0	0	0
Spasm	Perivascular stripping and injection & ganglion block	1	0	0	0
	Perivascular stripping & injection	1	0	0	0
Compression	Evacuation of hematoma & perivascular stripping	1	0	0	0
TOTAL		18	2	4	6

TABLE VI D

Mortality in 22 Cases with Injury of the Axillary Artery

	Number of Cases	Causes of Death Vessel Injury	Causes of Death Other	Total Deaths	Percentage	Unknown
Without Major Complicating Wounds	12	2 *	0	2	16.6	2
With Major Complicating wounds	10	1	1	2	20.0	2
TOTAL	22	3	1	4	18.2	4

* One of these cases died of Clostridial Myositis.

Arterial Injuries in War Wounds (Brachial arteries, contd) (Section "B", contd)

TABLE VII A

Relation of Type of Lesion to Limb Loss in 71 Injuries of the Brachial Artery

		*Amputations above Elbow	
Type of Lesion	Number of Limbs	Number	Percent
Transection	42	9	21.4
Laceration	17	1	5.9
Thrombosis	5	4	80.0
Spasm	7	0	0.0
TOTAL	71	14	19.6

* All amputations occurred above elbow.

TABLE VII B

Relation of Fracture to Limb Loss in 75 Injuries of the Brachial Artery

		*Amputations above Elbow	
	Number of Limbs	Number	Percent
No Fracture	45	5	11.1
Compounded Communited Fracture	30	9	30.0
TOTAL	75	14	18.8

* All amputations occurred above elbow.

Arterial Injuries in War Wounds (Brachial arteries, contd) (Section "B", contd)

TABLE VII C

Mortality in 77 Cases with Injury of the Brachial Artery

	Number of Cases	Causes of Deaths: Vessel Injury	Causes of Deaths: Other	Total Deaths	Percentage	Unknown
Without Major Complicating Wounds	46	2*	1**	3	6.5	16
With Major Complicating Wounds	31	0	11***	11	35.5	5
TOTAL	77	2	12	14	18.2	21

* Both deaths due to clostridial myositis.

** One death due to pulmonary embolus.

*** 5 deaths due to shock, 2 due to head injuries, 1 to pulmonary embolus, 1 to bilateral thoracic wounds, 1 to respiratory paralysis from spinal cord injury, and 1 to blast injury to brain and lungs.

TABLE VII D

Results of Various Types of Treatment of 71 Injuries of the Brachial Artery as Measured by Limb Loss

Lesion	Procedure	No. of Limbs	Amputations *
Lacerations and Transections	Ligation	36	5
	Ligation & stellate ganglion block	19	5
	Ligation & perivascular stripping	1	0
	Suture & stellate ganglion block	1	0
	Suture, stellate ganglion block & perivascular stripping	1	0
Thrombosis	No treatment	5	4
Spasm	No treatment	3	0
	Stellate ganglion block	1	0
	Perivascular stripping	4	0
TOTAL		71	14

* All amputations done above elbow

Arterial Injuries in War Wounds (Radial and ulnar) (Section "B", contd)

TABLE VIII

Radial and Ulnar Arterial Injuries

	Number of Limbs	Amputations		Deaths		
		Number	Percent	Number	Percent	Cause
Radial	14	1	71.4	1	71.4	Pulmonary embolism from femoral vein
Ulnar	10	1	10.0	1	10.0	Clostridial myositis in arm
Radial and ulnar	3	1	33.3	1	33.3	Clostridial myositis in leg wound

Arterial Injuries in War Wounds. (Femoral Arteries) (Section "B", contd)

TABLE IX A

Relation of Type of Lesion to Limb Loss in 68 Injuries of the Common Femoral, Superficial Femoral, and Deep and Superficial Femoral Arteries.

			Amputations						
Lesion	Vessel	No. of Limbs	Toes	Foot	Leg M/3	Below Knee	Above Knee	Total	Percent
Transection	C*	2					1	1	50.0
	S	22	1	2			7	10	45.4
	DS	2					2	2	100.0
Laceration	C	6					4	4	66.6
	S	26	2	2	4	3	1	12	46.1
	DS	2					1	1	50.0
Thrombosis	C	1							0
	S	3					2	2	66.6
Contusions	S	1							0
Spasm	C	2					1**	1	50.0
Compression	C	1		1				1	100.0
TOTAL		68	3	5	4	3	19	34	50.0

* C - Common Femoral alone
S - Superficial Femoral alone
DS - Deep and Superficial Femoral combined

** Combination of spasm of common femoral and laceration of the deep femoral. The latter required ligation. Death followed amputation for clostridial myositis.

Arterial Injuries in War Wounds. (Femoral Arteries, contd) (Section "B", contd)

TABLE IX B

Relation of Fracture to Limb Loss in 68 Injuries of the Common Femoral, Superficial Femoral, and Deep and Superficial Femoral Arteries.

	Vessel	No. of Limbs	Toes	Foot	Leg M/3	Amputations – Below Knee	Above Knee	Total	Per-cent
No Fractures	C*	9					5	5	55.5
	S	39	3	4	3	1	4	15	38.4
	DS	2					2	2	100.0
Compounded comminuted fracture	C	3		1			1	2	66.6
	S	12			1	2	5	8	66.6
	DS	2					1	1	50.0
Simple fracture	S	1					1	1	100.0
TOTAL		68	3	5	4	3	19	34	50.0

* C - Common Femoral alone
S - Superficial Femoral alone
DS - Deep and Superficial Femoral combined

Arterial Injuries in War Wounds. (Femoral Arteries, contd) (Section "B", contd)

TABLE IX C

Mortality in 76 Cases with Injury to the Common Femoral, Superficial Femoral and Superficial and Deep Femoral Arteries.

	Vessel	No. of Case	Causes of Death: Vessel Injury	Causes of Death: Other	No. of Deaths	Percentage	Unknown
Without major complicating wounds	C°	8	1"	2	3	37.5	8
	S	46	3 # # "	1	4	8.7	1
	DS	4	2 ¢ *		2	50.0	
With major complicating wounds	C	4	1 #		1	25.0	1
	S	13	3 ¢ # #	2	5	37.7	
	DS	1				0	
TOTAL		76	10	5	15	19.7	10

C° - Common Femoral alone
S - Superficial Femoral alone
DS - Deep & Superficial Femoral combined

" - Died of clostridial myositis
- Died of pulmonary emboli from the associated vein
¢ - Died of shock
* - Died of hemorrhage

Arterial Injuries in War Wounds. (Common Femoral Artery) (Section "B", contd)

TABLE IX D

Results of Various Types of Treatment of 12 Injuries to the Common Femoral Artery as Measured by Limb Loss

Lesion	Procedure	No. of Limbs	Amputations Foot	Amputations Above Knee	Amputations Total
Lacerations and Transection	Ligation	5		3	3
	Ligation & lumbar sympathetic block	1		1	1
	Ligation, surgical symp. & fasciotomy	1		1	1
	Suture & lumbar symp. block	1			
Thrombosis	Arteriotomy & lumbar sympathetic block	1			
Spasm	No treatment	1		1*	1
	Periarterial injection	1			
Compression	Perivascular stripping & lumbar symp. block	1	1		1
TOTALS		12	1	6	7

* Combination of spasm of common femoral artery with ligation of the deep femoral artery.

TABLE IX E

Results of Various Types of Treatment of 4 Injuries to Both the Deep and Superficial Femoral Arteries.

Lesion	Procedure	No. of Limbs	*Amputations
Laceration and Transection	Ligation & lumbar symp. block	1	1
	Ligation & surg. lumbar symp.	1	1
	Suture	1	
	Suture, perivascular stripping & lumbar symp. block	1	1
TOTALS		4	3

* All amputations occurred above the knee.

Arterial Injuries in War Wounds. (Superficial Femoral Artery) (Section "B", contd)

TABLE IX F

Results of Various Types of Treatment of 50 Injuries to The Superficial Femoral Artery as Measured by Limb Loss

			Amputations					
Lesion	Procedure	No. of Limbs	Toes	Foot	Leg M/3	Below Knee	Above Knee	Total
Lacerations and Transections	Ligation	13	2	1	2	1	3	9
	Ligation & lumbar sympathetic block	20	1	1		1	2	5
	Ligation & surg. lumbar sympathectomy	4		1	1	1	1	4
	Ligation, surg. lumbar, symp., & fasciotomy	1						
	Ligation, lumbar symp. block & fasciotomy	2		1			1	2
	Ligation & refridgeration	1						
	Suture	1						
	Suture & lumbar symp. block	1						
	Suture, & surg. lumbar symp. & perivasc. strip.	1			1			1
	Suture, lumbar symp.block, perivascular stripping, & fasciotomy	1						
	Suture, lumbar symp. block, & perivasc. strip.	1						
	No treatment	1					1	1
Thrombosis	Surgical Lumbar symp.	1					1	1
	No treatment	1					1	1
Spasm	No treatment	1						
TOTAL		50	3	4	4	3	10	24

Arterial Injuries in War Wounds (Popiteal arteries, contd) (Section "B", contd)

TABLE X A

Relation of types of Injury to Limb Loss in 57 Injuries of the Popliteal Artery

Lesion	Number of Limbs	Amputations Toes	Foot	Leg-M/3	Above Knee	Total	Percent
Severed	23	0	3	2	14	19	82.6
Lacerated	18	1	1	0	8	10	55.5
Thrombosed	7	0	2	0	3	5	71.4
Compressed	3	0	0	0	0	0	00.0
Spasm	6	0	0	0	5	5	83.3
TOTAL	57	1	6	2	30	39	68.4

TABLE X B

Relation of Fracture to Limb Loss in 57 Injuries of the Popliteal Artery

	Number of Limbs	Amputations Toes	Foot	Leg-M/3	Above Knee	Total	Percent
No Fracture	26	1	6	1	8	16	61.6
Fracture	31	0	0	1	22	23	74.1
TOTAL	57	1	6	2	30	39	68.4

TABLE X C

Mortality in 56 Cases with Injury of the Popliteal Artery

	Number of Cases	Causes of Death Vessel Injury	Other	Total Deaths	Percentages	Unknown
Without Major Complicating Wounds	38	0	1	1	2.6	14
With Major Complicating Wounds	18	1 *	2	3	16.6	2
TOTAL	56	1	3	4	7.1	16

* Clostridial Myositis

Arterial Injuries in War Wounds (Popiteal arteries, contd) (Section "B", contd)

TABIE X D

Results of Various Types of Treatment of 57 Injuries of the Popiteal Artery as Measured by Limb Loss

Lesion	Procedure	Number of Limbs	Amputations Toes	Foot	Leg-M/3	Above Knee	Total
Laceration and Transection	No treatment	1	0	0	1**	0	1
	Ligation	10	0	0	1	7	8
	Ligation & lumbar symp. block	18*	0	2	1	7	10
	Ligation with surg. lumbar symp.	4	0	0	0	3	3
	Ligation & fasciotomy	1	0	0	0	1	1
	Ligation & stripping	1	0	0	0	1	1
	Ligation, fasciotomy & lumbar symp. block	2	1	0	0	1	2
	Ligation, fasciotomy & surg. lumbar symp.	2	0	0	0	2	2
	Suture & lumbar symp. block	2	0	1	0	0	1
	Suture, fasciotomy & lumbar symp. block	1	0	1	0	0	1
	Suture, stripping & lumbar symp. block	1	0	0	0	0	0
Thrombosis	No treatment	2	0	1	0	1	2
	Arteriotomy & lumbar symp. block	1	0	0	0	0	0
	Lumbar symp. block	2	0	1	0	1	2
Compression	Fasciotomy	1	0	0	0	0	0
Spasm	Lumbar symp. block	2	0	0	0	2	2
	Stripping & lumbar symp. block	3	0	0	0	2	2
	Stripping & periarterial injection	1	0	0	0	0	0
	Periarterial injection & lumbar symp. block	1	0	0	0	1	1
	Stripping, periarterial injection & lumbar block	1	0	0	0	0	0
TOTAL		57	1	6	3	29	39

* One of these is a thrombosis which was ligated and treated with a symp.block.

** Lesion of vessel discovered at secondary amputation.

Arterial Injuries in War Wounds (Tibial arteries, contd) (Section "B", contd)

TABLE XI A

Relation of Type of Lesion to Limb Loss in 91 Injuries of the Tibial Arteries

Lesion	Vessel	Number of Limbs	Amputations Number	Amputations Percent
Laceration or Transection	Anterior tibial	20	2	10.0
	Posterior tibial	41	3	7.3
	Anterior & Posterior tibial	24	10	41.7
Thrombosis	Posterior tibial	1	1	100.0
	Anterior & Posterior tibial	2	1	50.0
Spasm	Anterior tibial	1	0	0.0
	Anterior & Posterior tibial	1	1	100.0
Compression	Anterior & Posterior tibial	1	0	0.0
TOTAL		91	18	19.7

TABLE XI B

Relation of Fracture to Limb Loss in 91 Injuries of the Tibial Arteries

	Vessel	Number of Limbs	Amputations Number	Amputations Percent
No Fracture	Anterior tibial	6	0	0.0
	Posterior tibial	25	1	4.0
	Anterior & Posterior tibial	8	6	75.0
Compounded Comminuted Fracture	Anterior tibial	15	2	13.3
	Posterior tibial	17	3	17.7
	Anterior & Posterior tibial	20	6	30.0
TOTAL		91	18	19.8

Arterial Injuries in War Wounds (Tibial arteries, contd) (Section "B", contd)

TABLE XI C

Mortality in 121 Cases with Injury of the Tibial Arteries

	Vessel	Number of Cases	Causes of Death Vessel Injury	Other	Total Deaths	Percentage
Without	A*	17	1	0	1	5.9
Major compli-	P	23	0	1	1	4.3
cating wounds	A&P	5	1	0	1	20.0
With	A	19	0	0	0	0.0
Major compli-	P	34	0	0	0	0.0
cating wounds	A&P	25	0	3	3	12.0
TOTAL		123	2	4	6	4.9

* A - Anterior tibial
P - Posterior tibial
A&P - Anterior & Posterior tibial

TABLE XI D

Results of Various Types of Treatment of 19 Injuries to Anterior Tibial Arteries as Measured by Limb Loss

Lesion	Procedure	Number of Limbs	Number of Amputations
Transection	Ligation	15*	1
and laceration	Ligation & lumbar symp. block	6	2#
Spasm	Fasciotomy & lumbar symp. block	1	0
TOTAL		22	3

* One patient had the anterior and the posterior tibial and the peroneal arteries ligated.

\# Each mark indicates presence of clostridial myositis.

TABLE XI E

Results of Various Types of Treatment of 44 Injuries to Posterior Tibial Arteries as Measured by Limb Loss

Lesion	Procedure	Number of Limbs	Number of Amputations
Transection and laceration	Ligation	32	1
	Ligation & lumbar symp. block	9	3##
	Ligation & fasciotomy	2	0
	Ligation, fasciotomy & lumbar symp. block	1	0
TOTAL		44	4

Each mark indicates presence of clostridial myositis.

TABLE XI F

Results of Various Types of Treatment of Injuries to both the Anterior & Posterior Tibial Arteries as Measured by Limb Loss

Lesion	Procedure	Number of Limbs	Number of Amputations
Transection and lacerations	Ligation	15	5###
	Ligation & lumbar symp. block	3	2##
	Ligation & surgical lumbar sympathectomy	3	2##
	Ligation & fasciotomy	2	1** #
	Ligation, fasciotomy & lumbar symp. block	1	1
Compression	Evacuation of hematoma	2	0
	Fasciotomy	1	0
TOTAL		27	11

** One patient had the anterior and the posterior tibial and peroneal arteries ligated.

Each mark indicates presence of clostridial myositis.

Arterial Injuries in War Wounds (Treatment)(Section "B", contd)

TABLE XII

Results of Various Types of Treatment of 4 Injuries of the Subclavian Artery as Measured by Limb Loss

Lesion	Procedure	No. of Limbs	No. of Amputations
Transection and laceration	Ligation	2	0
	Ligation with stellate ganglion block	2	1
TOTAL		4	1

TABLE XIII

Results of Various Types of Treatment of 3 Injuries of the Common Iliac Artery as Measured by Limb Loss

Lesion	Procedure	No. of Limbs	No. of Amputations
Transection and laceration	Ligation	1	1
	Suture	2	0
TOTAL		3	1

TABLE XIV

Results of Various Types of Treatment of 10 Injuries of the External Iliac Artery as Measured by Limb Loss

Lesion	Procedure	No. of Limbs	No. of Amputations
Transection and laceration	Ligation	3	2
	Ligation & lumbar symp. block	1	0
	Ligation & surgical lumbar symp.	1	0
	Sutured	2	1
	Sutured & lumbar symp. block	1	0
	Sutured & lumbar surgical symp.	1	1
Spasm	Lumbar symp. block	1	0
TOTAL		10	4

In considering the lesion and treatment tables it is readily apparent that thrombosis of an artery not ligated is followed by a high rate of limb loss. It is obvious that the theater policy of ligating and excising the thrombosed segment is well founded: Treatment by interruption of the regional or local sympathetics alone does not appear efficacious. Arteriotomy in a few instances was successful in saving the limb. However, such cases should be carefully selected so that arteries which are badly contused or the vessel wall anoxic over an extended time interval are excluded.

Spasm of arteries is not an innocous lesion for about one-fourth lost limbs. The groups treated by a variety of types of sympathetic interruption and the group receiving no treatment are too small to evaluate the treatment.

Arteries compressed by hematomas respond well to local decompression operations. This is commonly noted in compression of the tibial arteries.

The results of treatment of injuries of the popliteal artery are poor. The group in which the wounds of the vessel were repaired by suture resulted in the least limb loss. However, this comprised but a small part of the total injuries. It appears that any one or a combination of methods which aims at immediate restoration of the continuity and patency of the artery should be consistently tried.

Arterial Injuries in War Wounds (Section "B", contd)

TABLE XV A

Effects of Sympathetic Interruption on Limb Loss - Lower Extremity

	Ligation only			Ligation with Lumbar Sympathetic Block			Ligation with Lumbar Surg. Symp.		
	Total Limbs	Amputations No.	Amputations %	Total Limbs	Amputations No.	Amputations %	Total Limbs	Amputations No.	Amputations %
External iliac	5	2	40.0	2	0	0.0	2	1	50.0
Femorals*	18	12	66.6	22	7	31.8	9	8	88.8
Popliteals	10	8	80.0	17	10	58.8	6	5	83.3
Totals	33	22	66.6	41	17	42.4	17	14	82.4

* Common femoral artery
Superficial artery
Superficial and deep femoral artery

TABLE XV B

Effects of Sympathetic Interruption on Limb Loss - Upper Extremity

	Ligation only			Ligation with Stellate Block		
	Total Limbs	Amputations No.	Amputations %	Total Limbs	Amputations No.	Amputations %
Subclavian	2	0	0.0	2	1	50.0
Axillary	9	4	44.4%	9	2	22.2
Brachial	36	5	13.9	19	5	26.3
Totals	47	9	19.1	30	8	26.6

Review of the detailed treatment charts reveals such a variety of methods, and combinations of methods, with too few arterial injuries being treated in a like manner to make possible the drawing of many conclusions. However, by examining various arteries treated similarly in respect to sympathetic interruption it becomes evident that ligation with lumbar sympathetic procaine block is superior to simple ligation in treatment of injuries of the external iliac, popliteal and femoral arteries. Examination of the tables shows that limb loss following ligation with lumbar surgical sympathectectomy is approximately double the limb loss following ligation with lumbar sympathetic procaine block. The answer to this paradox probably lies in selection of patients. However, there is too little information on the preoperative condition of the limb to evaluate the specific cases for which surgical sympathectomy was done.

Arterial Injuries in War Wounds (contd)

TABLE XVI

Section "C"

Injuries of the Carotid Arteries

Age	Time lag	Shock	Preoperative examination	Associated injuries	Type and degree of vessel injury	Operative procedure: Vessel	Operative procedure: Other	Recoveries: Cerebral signs	Recoveries: Day evac	Comment and follow-up	Deaths: Day P.O.	Deaths: Cause
19	24'	No	Conscious. Rt Horner's syndrome, paralysis of rt diaphragm. No hemiplegia.	Transected rt phrenic and recurrent laryngeal n. Contused symp chain.	Rt C. C.* severed	Ligation of artery Elective lig. of int. jugular v.	None	None	?	Also had hemiparalysis of vocal cords		
	8'	Mod	Conscious. No hemiplegia	Contusion of 5th and 6th Cervical nerves.	Lt C. C. lacerated at bifurcation	Lig. of C. C., ext. & int. carotid and vertebral arteries left.	None	Rt hemiplegia. Lt facial paralysis	7			
29	8½'	No	Conscious. No hemiplegia		Lt C. C. lacerated near aorta & connected by fistula to int. jugular vein.	Quadruple ligation	None	None	6	Left-sided headache p.o.		
	2'	No	Conscious. No hemiplegia	Sucking thoracic wound	Rt C. C. lacerated near origin	Lig. rt C. C.	Closure of sucking wd.			Hemiplegia immediately p.o.	2	Encephalomalacia
25		Sev		Perforation of trachea	C. C. severed	Ligation of C. C.	Tracheotomy	None	3	No hemiplegia 18 days p.o.		
	11½'	No	Conscious. No hemiplegia		Rt C. C. lacerated	Ligation rt C. C.	Tracheotomy	Lt hemiplegia Lethargy	4	Hemiplegia and lethargy improving at time of evacuation.		
21	15 days		Conscious. No hemiplegia	Pen. wds. of face	Rt C. C. lacerated	Ligation rt C. C.	Tracheotomy	None		Original operation was tracheotomy. C.C. lig. for hemorrhage on 18th p.o. day.		
19	36'		Conscious. No hemiplegia	F. c. c. maxilla and mandible.	Lt C. C. lacerated	Ligation lt C. C.	None	None				
	8'		Unconscious	F. c. c. thyroid cartilage. Pen. wds arm & shoulder	Lt C. C. lacerated at bifurcation	Lig. of C. C., ext. & int. carotid arteries	None				10	Encephalomalacia
		Sev	Conscious. Quadriplegia & rt facial palsy	Contused superior & median cords of brachial plexus & phrenic n.	Lt C. C. thrombosed & lt int. jugular vein lacerated	Lig. of lt int. jugular vein				Autopsy showed thrombosed lt C. C. artery	4	Encephalomalacia
19	6½'				C. C. perforated	Lig. of C. C. & removal of damaged segment			13			
24	9½'		No hemiplegia	Pen. wd. of thorax	Lt C. C. lacerated near origin	Lig. of C. C.				Had hemiplegia p.o.	2	Encephalomalacia
24	3½'	Sev	Conscious. No hemiplegia	Perf. of cervical esophagus. Contusion lt phrenic nerve	Rt C. C. lacerated near origin. Rt int. jugular v. Lt vertebral a. transected.		Tracheotomy				Died before operation of hemorrhage from lt vertebral a. into pleural cavity.	

* C. C. - Common Carotid Artery

Arterial Injuries In War Wounds, Section "C" (Table XVI, contd)

Age	Time lag	Shock	Preoperative Examination	Associated injuries	Type and degree of vessel injury	Operative procedure: Vessel	Operative procedure: Other	Recoveries: Cerebral signs	Recoveries: Day evac	Comment and follow-up	Deaths: Day P.O.	Deaths: Cause
			Conscious. No hemiplegia	Pen. wd. of thigh	Lt C. C. lacerated	Lig. of C. C.*	Debridement			Semicomatose p.o.	5	"Cerebral death" No autopsy
[illegible]	[illegible]	No	Lt hemiplegia		Rt C. C. lacerated just before bifurcation. Int. jugular v. severed.	"Blakemore cuff" anastomosis using saphenous v. Int. jugular v. ligated.	Tracheotomy			Semicomatose p.o. Partial recovery from hemiplegia by 4th p.o. day.	19	Encephalomalacia
1[illegible]	2[illegible]	No		Pen. wds of knee, thoracic wall and face.	Lt C. C. intima bulged through laceration in muscularis. Lt subclavian v. lacerated at junction with int. jugular v.	Inversion of aneurysm and suture of muscularis. Ligation of veins		None	2	No interruption of blood flow at any time.		
		Sev	No hemiplegia	Contusion lt cervical sympathetics	Lt int. carotid a. thrombosed & lt ext. carotid a. severed.	Lt ext. carotid a. ligated.	Tracheotomy				9	Encephalomalacia. Thrombosis of int. carotid a. extending into cerebral vessels.
					Innominate a. laceration 2 cm. long 2 cm. from aorta.	Ligation of innominate artery.					3	Encephalomalacia. Perf. of cervical trachea and esophagus.

* C. C. - Common Carotid Artery

Table XVI includes 17 patients with common carotid artery injuries and one patient with injury to the innominate artery. In 13 of the patients the common carotids were lacerated, transected or perforated. Twelve of these arteries were ligated and one was treated by nonsuture anastomosis (Blakemore cuff). In two of the patients the arteries were thrombosed, and no surgery was done on either vessel. One injury was an acute aneurysm which was inverted and sutured. One acute arteriovenous fistula was treated by quadruple ligation.

Eight of the 17 patients with common carotid artery injury died (47.1%). Seven died of encephalomalacia. One with hemorrhage into the pleural cavity from a lacerated vertebral artery on the opposite side from the lacerated common carotid did not survive to reach surgery. Information relative to the preoperative condition was present in six of the seven patients dying of encephalomalacia. Only two of the six had a preoperative hemiplegia. The seventh patient was unconscious and the question of paralysis was not determined.

Data concerning preoperative hemiplegia were available on only six of the nine surviving patients. None of these six had a hemiplegia before surgery. There were two postoperative hemiplegias. Neither of these two patients had a hemiplegia before operation.

TABLE XVII

Acute Aneurysms and Arteriovenous Fistulas

Time lag	Lesion	Treatment	Associated operative findings	Complicating wounds and treatment	Results
24'	Intima bulged out through lacerated muscularis of left C.C.* artery.	Inversion of intima and suture of muscularis.	None	Penetrating wound of right knee. Arthrotomy.	Evac. 2nd p.o. day. Carotid pulse present.
14' 30"	Fistula between rt external carotid artery & internal jugular vein.	Ligation of artery and vein.	Compounded, comminuted fracture of rt humerous.	None	Evac. 3rd p.o. day. No cerebral signs or symptoms.
8' 30"	Fistula between lt C.C. artery and internal jugular vein.	Quadruple ligation	None	None	Evac. 5th p.o. day. No cerebral signs. Lt sided headache (?).
8' 30"	Fistula between upper portion of lt brachial artery and vein.	None	No operation for fistula.	Penetrating wound of abdomen. Resection of small intestine.	Died 1st p.o. day of shock and atelectasis.
4' 45"	Fistula between mid portion of lt brachial artery and vein.	Quadruple ligation and peri-arterial stripping.	None	None	Evac. 1st p.o. day. Brachial and radial pulse present.
7' 10"	Fistula between rt popliteal artery and vein just above bifurcation	Ligation during debridement followed by primary amputation.	Extensive loss of calf muscles.	None	Evac. 8th p.o. day. Uneventful recovery.
8 days	Pseudo-aneurysm of right popliteal artery.	Primary amputation for ischemic gangrene.	None	None	Evac. 4th p.o. day. Condition good.

* C.C. - Common Carotid Artery

10. ANAEROBIC INFECTIONS

ANAEROBIC INFECTIONS

A comprehensive report of this important subject in battle casualties cannot be prepared from the amount of data pertaining to this subject found in the records. However, one of this Auxiliary Surgical Group, Major Floyd H. Jergesen, was associated with Lt. Col. F. H. Simeone in the study and report of anaerobic infection in the Fifth Army between the 9th of September 1943 and the 29th of February 1944. The material of this report has been extracted and utilized freely in an attempt to give a picture of this infection in the forward hospitals. Data from the records of the 2nd Auxiliary Surgical Group are presented in respect to incidence in amputations and in association with wounds of the abdomen and chest.

Anaerobic infections have been the most serious infections encountered in the forward hospitals. Tetanus infection has virtually been absent. Only one case in an American soldier could be recalled from the records of this Group during 1943, 1944 and 1945. Three clinical types of anaerobic infection have been encountered, namely clostridial myositis, anerobic cellulitis and anerobic streptococcal myositis. The first two were met most often, while the last rarely occurred.

Clostridial myositis is used synonymously with gas gangrene and denotes the basic pathology of an acute invasive infection of the viable muscle by pathogenic clostridia. This infection is fulminating and fatal unless treatment is instituted early and energetically. As found in the study of Fifth Army, casualties with this infection, three-fourths developed in the lower extremity, one-eighth in the upper extremity and one-eighth in the trunk.

From the clinical point of view, the above-mentioned report to the Fifth Army gives a description of the Welch and Oedematiens types. The discussion of the two types is given below:

"<u>Welch Type of Clostridial Myositis</u>

"The average length of time from wounding until the diagnosis is apparent in the Welch type is approximately two days. The onset may be as early as six hours and practically all cases will occur within 10 days after wounding.

"Pain is the most frequent and most striking symptom. It may start as a dull aching pain or it may be of such severity as to simulate a major vascular crisis. The pain may be relieved by morphine or splitting a plaster casing. Sometimes it becomes progressively more severe until the overwhelming toxemia shrouds it. This symptom is of sufficient value that we have encouraged surgeons not to leave routine orders for morphine after 24 hours. As a general rule, a patient that requires a strong opiate for relief of pain in an extremity 24 hours after operation deserves the attention of his surgeon.

Anaerobic Infection (contd)

"Increase in the pulse rate is also of importance. The pulse rate of a patient with only extremity wounds and no appreciable secondary anemia should be under 100 at the end of the second postoperative day. A sustained pulse rate of approximately 120 or a rising pulse rate is a valuable sign of local trouble but by itself, it is not diagnostic.

"An elevation of temperature up to 102° to 103° is frequently found and is a characteristic of the Welch type of clostridial myositis. Occasionally, the temperature will rise rather precipitously from approximately normal to 104° at the onset.

"The mental symptoms accompanying the Welch type of clostridial myositis are striking. The patient is alert, apprehensive and acutely aware of his surroundings. This apprehension may be extreme. The patient constantly quizzes the surgeon concerning his progress. At times, personality changes have been noted. A patient who has been cooperative and appreciative will suddenly become hypercritical of the nurses or ward attendants' efforts. We have seen patients throw urinals on the floor, expectorate at nurses and curse the surgeons. As the toxemia disappears, the same patients would apologize, being acutely aware of their previous mental reactions. They remain mentally clear and answer questions rapidly and relevantly. We have repeatedly seen patients remain aware of thei surroundings until a few minutes before death.

"As the toxemia increases, the blood pressure gradually falls until the patient is in a state of shock. The rapidity of the fall of the blood pressure depends upon the severity of the infection. Along with the fall in blood pressure, the extremities become cold and the finger tips become cyanotic.

"Local examination of the wound is of paramount importance in making an early diagnosis. This can only be carried out satisfactorily with all the dressings removed, adequate light and exposure. It is generally necessary to take the patient to a room where aseptic technique can be carried out and anesthesia administered if necessary. The ordinary ward tent frequently does not provide an ideal place for such examinations. Careful examination of the wounds with adequate retraction will give invaluable information. It should be pointed out here that we do not advise or encourage malicious disturbance of wounds by frequent dressings. Our enthusiasm to give the patient the benefit of an early diagnosis can be a two-edged sword. However, the judicious examination of wounds has made it possible to diagnose these infections before the patient is moribund and in some instances to salvage extremities by local resections that a few hours later would require amputation.

"Two of the most fallacious and least reliable local signs are odor and crepitation. For instance, a wound infected by the clostridium perfringens with a minimal number of secondary invaders has practically no

odor. The foul, putrefactive odor generally associated with clostridial myositis for the most part is due to relatively nonpathogenic organisms, frequently the proteolytic clostridia. Subcutaneous crepitus is generally not an early finding. Frequently it does not appear at all. Gas in the muscle tissue is of some diagnostic value in this type of infection. It is only contributory and not pathognomonic. Gas in the connective tissue and along the fascial planes is a manifestation of the gas under pressure following the route of least resistance. Not infrequently gas will be found around the femoral vessels and sciatic nerve in the thigh, having dissected proximally from an infection in the calf. The extend of the gas in the fascial planes is not a manifestation of the extent of the clostridial infection. Gas in the muscle tissue and especially in muscle tissue that probably was not traumatized by the original injury is an important sign. An X-ray film of the involved area when gas formation has taken place will show a pennate distribution along the muscle fibers. The swelling of the extremity in this type of clostridial myositis is due for the most part to the gas in the soft tissues and to a lesser degree to a minor edema of the subcutaneous tissues.

"Early, the skin shows no discoloration but later, it may become cyanotic. If the soft tissues have been appreciably distended by gas, then the skin may be pale and marble-like in appearance due to the local anemia.

"The most valuable local sign is the appearance of the muscle tissue. Sometimes this cannot be adequately determined without exploration of the wound under general anesthesia with adequate retraction or even exploratory incisions. Early, the muscle exposed on the surface may be dark reddish-brown but after this has been removed or the muscle tissue examined some distance from the surface, the characteristic color changes will be noted. The muscle early is pale pink, later it becomes pinkish gray and then bluish-gray. The normal firm resiliency gives way to a softness that simulates the feel of a ball of cotton. Occasionally the muscle is pasty or mucoid in consistency. These alterations are probably due to the presence of associated proteolytic clostridia. A transverse section of the muscle bundles will show that the normal architecture has been destroyed in varying degrees, depending upon the progress of the infection. A transverse section of normal muscle tissue will show the individual bundles standing out quite clearly. Muscle involved by the Welch type of clostridial myositis loses this appearance and presents an almost homogeneous mass. The muscle is relatively dry. Very little fluid can be expressed. Contractility is lost early. Pinching or cutting the muscle fibers fail to elicit a response. Bleeding from the smaller vessels is absent. Nevertheless, bleeding from larger vessels may persist until relatively late in the progress of the infection. This infection spreads rapidly and in a few hours, the infected muscles, from origin to insertion, will be hopelessly involved.

Anaerobic Infections (contd)

"Oedematiens Type of Clostridial Myositis

"The average length of time from wounding until the clinical appearance of the Oedematiens type of infection is approximately five days, being somewhat longer than the Welch type of infection. A sharp increase in this type of infection has been noted during this campaign among those wounded in the region of major rivers. As a rule the onset is more insidious. Local pain is not an outstanding symptom. It is noted in somewhat less than half the cases and is not severe, being dull in character. A sensation of increased weight in the extremity may be one of the earliest complaints. This has been noted even in amputation stumps.

"The pulse rate as a rule is not as rapid at the onset as in the Welch type. Frequently it will fluctuate between 100 and 110 per minute but may increase to 130 to 140 late in the disease.

"If secondary bacterial invaders are minimal, the temperature is low, generally below 100°. However, with an associated aerobic or anaerobic infection there may be an elevation to 102° or 103°. It has been noted that following 48 hours of energetic treatment, the temperature will often rise from normal to 102 to 103 degrees.

"The mental symptoms accompanying the Oedematiens type of infection are almost the opposite of those of the Welch type. Very early, the patient shows no mental changes but as the toxemia progresses, he becomes less interested in his surroundings, gradually becoming listless, apathetic and somnolent. During this phase he will answer questions correctly but slowly. This bradyphrenia in a patient who has been previously alert is a very important sign. The answers to questions are deliberate and brief without an attempt to qualify or clarify the answer. As the toxemia progresses, the patient becomes stuporous. The sensorium becomes dulled to a point that the removal of dressings that ordinarily would be quite painful, causes little or no discomfort. This may be one of the reasons why local pain in the wound is not a characteristic early symptom. Occasionally, we have seen patients become maniacal after the stage of stupor. This acute mania lasts only a few hours, to be followed by an antemortal coma and then death.

"The blood pressure remains remarkably well sustained, in fact a slight increase in the systolic pressure has occasionally been noted. The blood pressure does not fall until relatively late in the progress of the disease. In one case the blood pressure remained within normal limits until five minutes before death. In spite of the unaltered blood pressure, the extremities become pale.

"Local examination of the wound in the very early stages may be very misleading unless it is carried out carefully and with utmost consideration of minor changes. Early, the extent of the involvement of muscle may be only in a small part of the wound. However, with good light and adequately exposed, the changes can be seen.

Anaerobic Infections (contd)

"The most important and striking of the local findings is serous exudate. Swelling of the affected part can be explained entirely on edema. Early in the disease, there is little if any gas in the tissues. Gas formation in this type of infection is a late manifestation. The skin early shows no changes, later it turns bronze and very late becomes bluish-purple with bleb formation. The extent of subcutaneous edema can sometimes be outlined in treated cases by the bronze discoloration of the skin a week or so after the diagnosis has been made. The amount of subcutaneous edema varies considerably with the progress and the stage of the infection. Very early, it may involve the subcutaneous tissue in one sector of the wound. Late, it has been seen to extend from a thigh wound up over the anterior abdominal wall, buttocks, chest and reach the scapular region. The outpouring of fluid into the tissues has been so marked in some cases as to cause hemoconcentration. The edema of the muscle early may be limited only to a small area. As it progresses, the muscle becomes more swollen and bulges from the wound, the skin edges become everted and porky in consistency. The dressings become saturated, as do the plaster splints and bed covers. The consistency of the muscle tissue early is slightly firmer than normal, and just before gas formation starts, it becomes almost cartilagenous in firmness. Early the color is paler than normal, being pink and having a waxen appearance. This persists until very late when the muscle turns deep red, reddish-brown, purple and then black. It is during this stage of rapid color changes that gas formation takes place. During the stage that the muscle is pink and waxen, the wound generally has a gelatinous membrane over its surface. This gelatinous membrane is probably the fibrin of the normal blood clot from which the red cells and hemoglobin have been washed by the outpouring of serous fluid. Frequently, bright scarlet, stellate fleks of altered hemoglobin can be seen in this gelatinous membrane. The involved muscle loses its contractility early but uninvolved adjacent areas may continue to contract. The muscle retains its blood supply until relatively late, even being hyperemic. When one of the involved tufts of muscle is cut, there is a profuse oozing of blood and serous exudate. Late in the disease, just before the color changes and gas formation, the blood supply is destroyed. Sections of such areas will grossly show thromboses of the smaller vessels. Even in fatal cases, it is surprising to see how little muscle tissue has been involved. At autopsy it has been repeatedly noted that muscle eight to 10 cm. from the wound is grossly normal.

"Laboratory findings are not of great value in making a diagnosis. Smears of the wound are of value only in differentiation from anaerobic streptococcal myositis. The most striking laboratory finding is the blood count. There is almost always a secondary anemia of varying degree. In a few cases, the blood sugar has been found to be lowered. Plasma proteins are generally decreased. The hematocrit may be elevated during the phase of exudation in the Oedematiens type.

Anaerobic Infections (contd)

"The infections are rarely pure. They are almost always associated with other organisms, many times giving bizzare and confusing clinical pictures according to the associated organisms. Subsequent aerobic and anaerobic saprophytic infections in these wounds are the rule. These secondary infections many times are quite difficult to treat. The subsequent anaerobic saprophytic infections follow the clinical course of anaerobic cellulitis for the most part."

The diagnosis then was based on clinical observation of the patient and his wounds. The use of smears of the wound was of little significance in arriving at a diagnosis. It was sometimes necessary to make exploratory incisions into the muscle to determine the diagnosis.

In the prophylactic treatment, the most important factor was the early and complete debridement of wounds. The gas antitoxin, as given, and sulfonamide did not seem to be a determining factor in the prevention of infection. The role of penicillin cannot be discussed due to lack of evidence at the present. The early use of transfusions of blood in overcoming anemia should not be neglected.

In the curative treatment of clostridial myositis antitoxin was effective in controlling the toxemia of the disease. An initial dose of 10 vials and subsequent doses of five vials every eight hours was the usual schedule employed. The role of sulfonamides seems to be the control of secondary invaders rather than of the clostridial infection. Again transfusion of blood was extremely important because of the rapidly developing anemia in this infection. Penicillin as used in these cases was administered with an initial dose of 100,000 units intravenously and 20,000 to 25,000 units every three hours by the intramuscular route thereafter. It is felt that penicillin is a valuable adjunct to surgery in the treatment of clostridial myositis.

In the experience of the Fifth Army report the place of operative treatment in the cure of this infection was as follows:

"The most important phase of treatment is operative. The anesthesia of choice in these cases is ether and oxygen. As a rule, anemic and toxic patients have not reacted well under pentothal anesthesia. Spinal anesthesia with the concomitant peripheral vascular dilation, may increase absorption from soft tissues laden with toxins.

"Adequate supportive treatment in the form of blood, plasma and dextrose solution during the operation may be the decisive factor in making it possible to prolong the procedure until all infected tissue has been removed.

"Occasionally, it has been possible to salvage a patient's life by the application of a very tight tourniquet. Sometimes, a diagnosis is not made until the patient is profoundly toxic. In such condition, any

major operative intervention would not be wise. A physiological amputation by means of a very tight tourniquet, above the infected area if possible, may reduce absorption until energetic supportive measures resuscitate the patient to a point that a surgical amputation can be performed above the tourniquet. The period between physiological and anatomical amputation has been as long as 24 hours with survival of the patient.

"As far as extremities are concerned, the question immediately arises whether local excision or amputation should be done. Before penicillin was available, 11 cases had local excisions and all of those patients died. Furthermore, practically all cases that were amputated through infected muscle tissue subsequently died. With the availability of penicillin, it has been feasible to do a greater number of local resections. Moreover, a high percentage of cases that have been amputated through infected muscle tissue have also survived with the concomitant administration of penicillin.

"As far as the Oedematiens type of infection is concerned, frequently a diagnosis can be made sufficiently early so that no muscle tissue need be removed primarily. Sometimes it is quite difficult in this type of infection to decide during the phase of toxemia how much diseased muscle will subsequently survive. If the diagnosis has been made early and the major arteries are uninjured, we have elected in a number of instances to insure adequate drainage and await demarcation. It has been gratifying to see muscle tissue recover that was originally thought to be beyond salvation. However, in sharp comparison with the Oedematiens type of infection, the Welch type of infection has always irreparably destroyed some muscle tissue. It is of paramount importance to thoroughly remove this diseased muscle. As a general rule, the decision whether to attempt local resection or to amputate will be made by the extent of the infection. The exposure of major arteries and nerves to sepsis and trauma without adequate soft tissue protection should not be done. When amputation is necessary, it should be done through normal muscle tissue if possible."

The most common type of anaerobic infection encountered was the anaerobic cellulitis. This was seen as an acute infection of devitalized soft tissue. It was invasive, but spread for the most part in connective tissue and is synonymous with "gas abscess". This infection was encountered where there was severe tissue trauma, interference with blood supply, and inadequate or lack of wound debridement. One of these factors was generally present in the case with anaerobic cellulitis. These were seen most commonly in the extremity or buttocks. This infection, as described in the report to the Fifth Army, was as follows:

"The length of time from wounding until the diagnosis is apparent is approximately three to five days. General symptoms accompanying the infection as a rule are not dramatic. Frequently, the infection is discovered during a routine dressing or while attempting to explain minor elevations of the temperature or pulse. Pain has been rather uncommon. When present it has not been severe.

Anaerobic Infections (contd)

"Fever, when present, has been moderate as a rule but on occasion during the spread of an infection or when larger areas are involved, daily fluctuations between 101° and 103° have been noted.

"The pulse rate is generally elevated but roughly follows the temperature curve. No changes in the mental status of the patient has been noted.

"Examination of the wound is the most important diagnostic method. Odor is invariably present. It is generally foul and putrefactive. Gas is present in varying amount. It is not uncommon to elicit subcutaneous crepitus 20 cm. away from the wound. The gas is present for the most part in the fascia planes and spreads along the fascial planes. The extent of the infection cannot be judged by the extent of subcutaneous crepitus. When gas is present in muscle tissue it does not extend further than the muscle that has been devitalized by the initiating trauma. Edema of the fascia may be present but it is not impressive.

"Examination of the depths of the wound reveals thick grayish-white pus in varying quantities along with shreds of devitalized soft tissues. The wound not infrequently is lined with a shaggy-grayish-white, diphtheritic membrane. When this membrane is cut away, normal, healthy, bleeding, contractile muscle is quickly encountered. To be sure, where such an infection has gone untreated for days, the adjacent muscle tissue may be somewhat edematous. However, the edema of the muscle tissue is not extensive. Its limitation can be somewhat anticipated by the extent of fascial involvement. As an example, if the fascail sheath of the rectus femoris is involved for a distance of 6 cm. from a lacerated wound of the mid thigh that has been untreated for a period of five days, it would not be unreasonable to expect some edema of the corresponding underlying muscle. Careful examination of the fascial planes will show purulent exudate preceded by edema. Ahead of this serous exudate, it is not uncommon to find some gas. Discoloration of the skin has not been noted except as a manifestation of subcutaneous hemorrhage from the original trauma. Redness of the skin and local tenderness has been noted at times when concomitant pyogenic invaders are present."

The smear of wound organisms was of no value in arriving at the diagnosis, which was made entirely on clinical observations. The prognosis in this type of infection is good. Prophylactic treatment is surgical and dependent upon early excision of devitalized tissue and incision of fascial planes for drainage.

Likewise the curative treatment of this infection is based upon the surgical removal of devitalized tissue and wide drainage. Cases that came to amputation with this infection did so more because of factors such as interruption of the blood supply to the part or extensive original tissue damage rather than because of the infection alone. Penicillin was felt to be a valuable adjunct to surgery in the control of infection. Antitoxin and sulfonamides were used also, without decisive results.

Anaerobic Infections (contd)

The rarest type of anaerobic infection encountered was anaerobic streptococcal myositis. It was an invasive infection of muscle and connective tissue. A description of a few cases seen in the report to the Fifth Army was as follows:

"The onset in one case was two days after injury and the other was five days. Both patients had a moderately elevated temperature and pulse rate. Both complained of pain in the wound which was not marked and was described as "soreness".

"Examination of the wounds showed edema of the subcutaneous fascia, intramuscular fascia and muscle. The muscle involvement seemed to be focal rather than diffuse. Early, circumscribed areas of firm pale muscle were noted, these later become whitish-gray, then began to liquify, coalesce and form a small amount of gas. The muscle tissue adjacent to these foci appeared grossly normal in every respect except for some edema. There was a foul odor from the wound. In one sector of the wounds, the skin and subcutaneous tissue had become gangrenous. Elsewhere in both wounds, the skin showed a slight erythema.

"The local process stubbornly progressed in both instances and was controlled only by rather energetic measures. Local resection of the involved muscle tissue did not stop the progress although it was repeated twice in one instance and three times in another.

"Penicillin parenterally, sulfonamides orally and Zinc Peroxide locally, slowly arrested both infections. In one instance, penicillin was discontinued before all infected tissue was removed and reactivation of the local process started immediately. After the progress of the infection has been controlled, the local use of continuous warm wet dressings has aided drainage and hastened the separation of necrotic tissue."

In addition to the discussion of anaerobic infection taken from the report to the Fifth Army, the incidence of the infection as encountered in the records of the 2nd Auxiliary Surgical Group are presented.

There were 108 amputations performed for anaerobic infection out of a total of 1357 amputations -- a rate of 7.9%. In all of these amputations, except in 11 instances, there was some interference with blood supply to the part in addition to the anaerobic infection. In the postoperative complications of the cases that had initial amputation for cause other than infection, clostridial myositis occurred in 16 instances and anaerobic cellulitis was present twice. In this entire group in which 108 amputations were performed for anaerobic infection, 16 deaths occurred from anaerobic sepsis.

In abdominal and thoraco-abdominal cases done by this Group in the forward hospitals there were 21 anaerobic infections recorded. Of these there was one case involving the abdominal wall and five the retroperitoneal space. All six of these patients died. In the remaining 15 in-

stances the anaerobic infection involved the buttocks or extremity and six of these had fatal outcome.

Intraperitoneal Clostridial Infections

Although not included in the 1944-45 statistical survey, at least five cases of fulminating intraperitoneal clostridial infection were seen during the latter part of 1943 by members of this Group. These cases presented a striking clinical and pathological picture that was not difficult to recognize once it was seen.

All five patients were admitted to the hospital within twenty hours of wounding, the earliest within four and one-half hours. Uniformly, they showed certain clinical signs and symptoms. These were: (1) shock to an extreme degree, with no response to intensive resuscitation therapy, (2) severe abdominal pain the conscious patient, unrelieved by morphine, (3) mental symptoms, ranging from acute apprehension and agitation to profound coma, the latter resembling the coma seen in some severe head injuries, (4) subcutaneous and intramuscular emphysema which was progressive, (5) tympanitic abdomen, with shifting dullness, (6) free gas in the peritoneal cavity on roentgen examination, and gas bubbles in the abdominal wall, (7) an odor of the wounds suggestive of clostridial infection.

Four of the five cases were operated upon, the fifth died before surgery could be undertaken. In the four surgical cases, the following was noted: A large amount of foul-smelling free gas escaped on opening the peritoneum. The abdomen contained quantities of very black, thin fluid. There was no evidence of peritoneal defense, no fibrin formation, and no localization. In this there was a marked difference from the peritoneal status exhibited by the cases of "overwhelming contamination", for in this latter type of case there was always present some fibrin deposits. The color of the intestine, particularly of the portions in contact with the peritoneal fluid, was purplish black, and appeared quite gangrenous, yet without the fibrinous coating usually seen on other types of gangrene. The whole picture resembled that of a massive acute mesenteric thrombosis more than anything else. There was little swelling of the intestinal wall. On section of vessels in the mesentery and of the intestinal wall itself, thrombi were seen to fill each vessel, particularly the veins, and bleeding did not occur except from the larger branches of the mesenteric artery. Gas was seen retroperitoneally and between the leaves of the mesentery if the missile had traversed these areas, otherwise it was not. In all cases the colon was perforated or lacerated.

Two of the four patients died before surgery could be completed. The other two lived for 6 1/2 and 10 hours after operation respectively, and in spite of continuous infusions at no time developed a systolic pressure of above 80. Death, with preterminal coma, resulted.

All patients had post-mortem examination. The one patient who died before surgery was admitted to the hospital in deep coma and shortly died. Post-mortem revealed no evidence of head or brain injury. In no case was findings other than described above encountered at autopsy. One case showed a pure culture of cl. welchii from the peritoneal fluid. Laboratory reports were not received on other smears and cultures taken.

In the group of thoracic cases treated in forward hospitals, there were two cases recorded who had anaerobic infection of the chest wall. Both of these patients died.

Infections of the pleural cavity have been encountered of the foul anaerobic type in which the predominating organism was clostridial. One of these cases showed gas bubbles throughout an intrapleural thrombus on roentzen ray examination. The toxicity and course of these patients did not differ from foul empyemas caused by other organisms.

SUMMARY AND CONCLUSIONS

1. The report to the Fifth Army of Simeone and Jergesen has been extracted in order to give a picture of anaerobic infection. The value of this work in the clarification of the subject, and in directing the treatment of anaerobic infection in the forward hospitals is emphasized.

2. A summary of the incidence of anaerobic infections, as encountered in forward hospitals by the surgeons of the 2nd Auxiliary Surgical Group, is presented as seen in the main first priority casualties, i.e. amputations, abdominal and thoraco-abdominal, and thoracic cases.

POST-TRAUMATIC RENAL FAILURE

POST-TRAUMATIC RENAL FAILURE

It has been recognized for a considerable period of time that traumatic shock is associated with a scant urine output. The cause of oliguria is believed to be the reduction in the glomerular filtration pressure which occurs when the systemic blood pressure falls. As long as the filtration pressure remains low, oliguria persists and azotemia ("pre-renal") results. It is ordinarily believed that adequate restoration of the blood pressure will result in the resumption of urine excretion and that damage of the renal parenchyma, if present at all, is not appreciable. In the presence of hypotension it becomes extremely difficult to evaluate the functional capacity of the kidneys per se, and in the presence of shock the decreased renal function is commonly attributed to the inadequacy of the circulation. The extent to which the renal circulation is decreased in shock has been studied in man. Lauson et al[1] have shown that traumatic shock is associated with a marked reduction in renal blood flow which cannot be explained upon the basis of the fall in blood pressure alone and they believe that renal vasoconstriction is responsible for the disproportionate renal ischemia. By means of this vasoconstriction blood is shunted from the kidneys to the central circulation (lungs, heart, and brain). They also cite evidence to indicate that the renal ischemia may be so marked in severe or prolonged shock that irreparable kidney damage results and that kidney failure persists after restoration of the circulation to a normal level. In the severely wounded, death often occurs within 24 to 48 hours after operation, and during this period of survival shock of varying severity and duration is commonly observed. In most instances a decreased or absent urine output may be completely explained upon the basis of shock and decreased renal blood flow. However, it is no longer possible to assume that damage of the renal parenchyma has not occurred even though evidences of pre-renal oliguria predominate in these cases, (loc. cit.).

Observations upon severely wounded men have tended to confirm the earlier impressions of Lauson and his associates and it has been found that certain patients may survive the immediate postoperative period only to die subsequently of renal failure. Furthermore, this renal failure cannot be satisfactorily explained by the usual concepts of pre-renal oliguria and azotemia since the blood pressure is normal or definitely elevated. Autopsy studies first called attention to the fact that pigment nephropathy and renal failure were not uncommonly observed in the severely wounded who required large volumes of blood in their resuscitation.

Lately more extensive studies have been carried on in this theater by The Board for the Study of the Severely Wounded. (A detailed report of the findings of this group is now in the process of preparation. Through the kind permission of the members of the Board we have been able to peruse much of this data. We gratefully acknowledge the help of Lt Col H.K. Beecher, Consultant in Anesthesiology and Resuscitation. Without the interest of Col E.D. Churchill, Surgical Consultant, Med. Theater of Operations a study of this material would not have been possible.)

Post-Traumatic Renal Failure (contd)

It is difficult to determine accurately the incidence of renal failure among all patients. Many instances of transitory oliguria are not recorded, particularly when the patient survives injury and operation without a complicated postoperative course. An attempt has been made to determine the incidence of oliguria or anuria in the group of 957 cases of intra-abdominal injury previously studied ("The Problem of Shock Therapy in Abdominal Wounds," see page 122). The incidence of oliguria or anuria among the patients who died in the Field Hospitals is shown in the following table. No patient who died sooner than 48 hours after operation is included in this analysis since the effects of existing shock serve to explain the decreased urine output in the majority of these patients.

TABLE I

ADMISSION SYSTOLIC BLOOD PRESSURE (mm. Hg)	Total No. Patients	No. of Patients Who Died	No. Patients Showing Oliguria or Anuria Before Death	COMBINED INCIDENCE OF ANURIA AND OLIGURIA	
				In fatal cases	In all cases
0-40	140	93	10	10.8%	7.1%
41-70	121	61	3	4.9%	2.5%
71-100	250	95	6	6.3%	2.4%
101-120	446	81	5	6.2%	1.1%
TOTAL	957	330	24	7.3%	2.5%

The most significant finding in this analysis is the increase in the incidence of oliguria and anuria as the degree of shock increased; a definitely higher incidence of renal failure is seen among the patients in the 0-40 mm. group than in the other three groups.

Recent studies in this Theater[2] have shown that the level of the non-protein nitrogen rises following injury and that initial levels are higher when shock is severe than when shock is absent or mild. Should diminished urine volume persist after operation there is a progressive rise in the non-protein nitrogen until death or diuresis occurs. Furthermore, when the non-protein nitrogen reaches 65 mgms per cent or above, 70% of such patients die.

In postmortem studies of patients with renal failure a distinct pathological entity has been observed. In brief, the microscopic findings are characterized by the precipitation of pigmented casts in the renal collecting tubules. Secondary intranephric hydronephtosis,

Post-Traumatic Renal Failure (contd)

degeneration and regeneration of tubular epithelium, and interstitial inflammatory changes may be noted at various stages depending upon the duration of the lesion before death occurred. This lesion is indistinguishable from that which follows the transfusion of incompatible blood and early in our experience the term "hemoglobinurie nephropathy" was used to designate the microscopic changes. Now it appears that "pigment nephropathy" is more exact since considerable evidence exists that the pigment is not always hemoglobin (however the abbreviation "H. nephropathy" has been retained in Chart I). Other terms applied to this lesion are "shock kidney" and "lower nephron nephrosis".

Since renal failure has been observed to be followed by the demonstration of pigment nephropathy at autopsy a clinicopathological analysis of patients dying with this lesion is of interest, (see Figure 96).

Complete autopsy studies have been made upon 51 severely wounded men who died in the Field Hospitals. At the present time reports of the microscopic study of the kidneys are available in 33 of these cases*. This small series has been analyzed from the standpoint of renal pathology and 16 cases (48.4%) were found to have the microscopic diagnosis of pigment nephropathy. In two cases the changes were slight or only moderately severe; in 14 cases (42.4%) there was severe or very severe involvement.

That these patients were severely wounded is evidenced by the fact that, in 14 cases (excluding from the total one case of burn and another case with only slight renal changes) the average admission blood pressure was 77/46. The average total** replacement therapy was 1200 cc. of plasma and 3260 cc. of citrated blood (15 cases, burn excluded). Two patients each received 6500 cc. of blood before and during surgery. Further evidence of the severity of shock and injury is afforded by the fact that eight of these 14 patients (57%) had received plasma (an average of 500cc. per patient) prior to reaching the Field Hospital.

Early in this study it was felt that the transfusion of a large volume of blood (Group O) which contains anti-A and anti-B agglutinins was the most important factor in the production of pigment nephropathy. It was thought that such changes would occur only in patients whose erythrocytes were susceptible to agglutination and hemolysis by these antibodies, i.e. Group A, B and AB. However, the incidences of patients belonging to the four blood groups are roughly the same in this small series as in the general population. Hence massive universal donor transfusions do not explain all cases in which typical renal lesion are found.

* A clinicopathologic correlation such as this pre-supposes the inclusion of microscopic study of autopsy material. For such reports, we are deeply indebted to Lt Col Tracy B. Mallory and Capt Leslie S. Jolliffe of the 15th Medical General Laboratory and Capt Joseph G. Rothenberg of the 1st Mobile Medical Laboratory. They have also given freely of their time in numerous personal communications.

** The total plasma and total blood given from the time of injury to end of operation.

PIGMENT NEPHROPATHY

CLINICO-PATHOLOGICAL ANALYSIS OF SIXTEEN FATAL CASES

SHOCK TEAM NUMBER 6

CASE NO.	AUTOPSY NUMBER	ADMISSION BLOOD PRESSURE (mm. Hg)	TYPE OF INJURY	REPLACEMENT THERAPY: PLASMA ***TOTAL	REPLACEMENT THERAPY: BLOOD PRE-OP.	REPLACEMENT THERAPY: BLOOD SUBS.	REPLACEMENT THERAPY: BLOOD TOTAL	BLOOD PRESSURE (post-op. da)	URINE OUTPUT**	EDEMA	STUPOR	JAUNDICE	SERUM HB.	HOURS INJURY-DEATH	POSTMORTEM FINDINGS: GROSS	POSTMORTEM FINDINGS: MICROSCOPIC LESION	POSTMORTEM FINDINGS: MICROSCOPIC DEGREE	CHIEF CAUSE OF DEATH
1	? Group B	100/80	Abdomen via left hip. multiple bowel perf. fract. ilium, left.	1500	*1500		*1500	170/100 (3rd)	olig. 1	none	slight	none	-	106	Pulmonary congestion & edema, severe. Right ventricular dilatation, acute.	H. nephropathy "Uremic Pneumonitis" Pul. fat embolism	severe mod. severe	Pulmonary edema Uremia
2	? Group A	124/78	Abdomen via rt. hip & lumbar region, right. multiple bowel perf. lac., rt. kidney, sev.	500	*500	*2500	*3000	122/76 (7th)	anuria	none	mod.	none	-	184	Peritonitis, localized, acute, sev. Pulmonary congestion & edema, slight. Nephrectomy, right, surgical.	H. nephropathy Bile stasis, hepatic	severe mod.	Uremia (NPN 240 mg %) Peritonitis
3	6 Group ?	40/40	Burns, phosphorous. 3rd deg., face & head 2nd deg., hands, arm & thigh, right.	2750	*500	*500	*1000	?	?	-	none	none	-	80	Edema, glottis & trachea, thermal. Pulmonary congestion & edema, severe. Bronchopneumonia, confluent, severe.	H. nephropathy	mod.	Pulmonary edema Broncho-pneumonia
4	12 Group A	110/60	Abdomen via left hip lac. iliac vessels massive hemorrhage	750	500	4500	5000	100/40 (?)	anuria	none	none	none	-	58	Perf.(2), ascending colon; retroperitoneal cellulitis, mod. severe. Pulmonary congestion & edema, mod. Ischemic leg, left.	H. nephropathy No evidence of vol. muscle necrosis.	severe	R-peritoneal cellulitis Pulmonary edema.
5	15 Group A	84/20	Abdomen via right hip lac. iliac vessels massive hemorrhage, hematoma, retroperit.	2000			4000	94/30 (2nd)	anuria	none	mod.	none	slight	90	Perf.(2), cecum. Clostridial infection of hematoma. Pulmonary congestion & edema, slight. Ischemic leg, right.	H. nephropathy "Hemolytic spleen"	severe mod.	R-peritoneal infection
6	19 Group ?	108/80	Thoraco-abdominal, rt. hemothorax contaminated by Clostridia.	1000			*2000	?	anuria	none	mod.	mod.	marked	76	Lung abscesses, multiple, bilateral. Pleuritis, fibrinopurulent, acute, right.	H. nephropathy Lung abscesses, coexisting.	severe severe	Multiple lung abscesses
7	23 Group AB	40/0	Abdomen via left hip: lac. obturator & vesicular veins: massive hemorrhage. multiple bowel perf.	1750	2500	4000	6500	180/100 (3rd.)	anuria	none	slight	none	-	68	Pulmonary congestion & edema, severe. Peritonitis, fibrinopurulent, healing	H. nephropathy	severe	Uremia Pulmonary edema.
8	24 Group C	70/50	Abdomen via right hip: massive necrosis of gluteal muscles. perf.(2), ileum. fracture, sacrum.	1000	2500	1000	3500	178/120 (2nd)	anuria	mod.	mod.	none	none	144	Phagedenic infection, gluteal & lumbosacral regions, very extensive. (Clostridial and suppurative myositis) Pul. cong., edema & atelectasis, mod. Bronchopneumonia, early, acute. Right ventricular dil., acute, severe	H. nephropathy Pul. fat embolism	severe mod.	Clostridial and suppurative myositis Uremia
9	27 Group O	128/70	Abdomen; evisceration of colon & ileum. multiple bowel perf.	2500			2500	90/60 (1st)	olig.	none	mod.	none	-	60	Peritonitis, gen., acute, severe. Pulmonary congestion & edema, mod. Bronchopneumonia, acute, severe.	H. nephropathy Bronchopneumonia	mod. severe	Peritonitis Broncho-pneumonia.
10	28 Group O	80/42	Multiple wds. buttocks, bilateral, severe. Laceration & avulsion of the rectum.	750	2000	1000	3000	120/80 (1st)	?	none	coma	none	-	34	Pulmonary congestion & edema, right, very severe; left, mod. severe. (? due to position of patient) ? myocardial insufficiency, acute. Sub-epicardial hemorrhage, multiple, extensive.	H. nephropathy Pul. fat embolism Sub-epicardial hemorrhage.	mod. mod. severe	Pulmonary edema. Asphyxia Cardiac failure.
11	29 Group A	110/76	Thoraco-abdominal, left. No bowel perforation.	250	1000		1000	?	no Olig.	none	none	mod.	-	148	Pleuritis, left, pericarditis, and peritonitis, gen., acute. (? due to pneumococci) Bronchopneumonia, confluent, acute.	H. nephropathy Bronchopneumonia, confluent.	slight severe	Poly-serositis, purulent.
12	30 Group ?	80/50	Thorax, right. Buttocks, bilateral: perf. of rectum. Fract., ribs & pelvis.	1250	1400	500	1900	?	?	none	severe	none	-	120	Infarct, traumatic, right lung, lower lobe. Cerebral infarct, premotor. Pulmonary congestion & edema, mod.	H. nephropathy Pul. fat embolism	severe mod.	Cerebral infarct. Pul. edema. Uremia.
13	33 Group O	60/30	Multiple wds. of legs, very severe. Multiple fractures of long bones. Clostridial myositis Sec. amputation.....	1500	1500	2000	3500 2500	118/70 (3rd)	anuria	mod.	severe	none	-	126	Clostridial myositis, both legs; very extensive muscle necrosis. (Required sec. amputation & fasciotomy) Pulmonary congestion & edema, mod. Pul. infarct, recent, rt. lower lobe. B-pneumonia, mult. abscesses R.L.	H. nephropathy Voluntary muscle necrosis Pul. fat embolism Lung abscesses	severe severe mod.	Uremia Lung Abscesses.
14	34 Group 1	90/54	Thoraco-abdominal, rt., severe; laceration of liver, severe. No bowel perforations.	750	1000	500	1500	145/90 (4th)	anuria	mod.	mod.	none	-	139	Pleuritis, rt, fibrinopurulent, acute, severe; with effusion (bile-stained) Pulmonary congestion & edema, mod. Bronchopneumonia, bil., acute, severe.	H. nephropathy "Uremic pneumonitis" Central necrosis of the liver.	mod. severe mod.	Pulmonary edema Uremia Broncho-pneumonia.
15	40 Group O	0/0	Abdomen: laceration & avulsion, transverse colon. Multiple perf. of small bowel.	2000	1500	1000	2500	very low through-out.	anuria	none	severe	none	-	36 ?	Peritonitis, gen., fulminating. Pul. cong., edema & atelectasis, mod.	H. nephropathy Spleen, focal necrosis.	mod. mod.	Peritonitis.
16	44 Group O	0/0	Abdomen via right hip: lac - ext. iliac & com. gluteal a. & vv. perf., ileum. Fracture, ilium, right.	250	2500	2500	5000	160/80 (4th)	anuria	none	slight	mod.	-	96	Pulmonary congestion, edema and atelectasis, very severe. Right ventricular dilatation, acute, moderate. Dry gangrene, right leg, early	H. nephropathy Pul. fat embolism	severe severe	Pulmonary edema & fat embolism Uremia.

"Group" refers to blood group. Replacement therapy expressed in cc. * Blood with unknown iso-agglutinin titre (pre-blood bank) *** Total plasma is the summation of plasma received from injury to end of surgery.
** Urine outputs - olig. - 100-600 cc/day; anuria - less than 100cc/day.

Post-Traumatic Renal Failure (contd)

From the clinical standpoint, oliguria or anuria* was noted more frequently in those who survived for three to five days. If the patient died within a relatively short time after operation, mention of oliguria was often not made. Anuria was noted in ten of the 16 cases (62.5%); oliguria was probably present in two additional cases; in one case oliguria was not present; in three the urinary output was not known. When noted, oliguria was found within 24 or 36 hours after operation, though it appeared to have been present from the time of operation. Dependent edema was infrequent (three cases - 19%), whereas pulmonary edema was the most common terminal physical sign, occurring in all but three cases (81%). Also, in 81% some degree of depression of the sensorium was noted; most often this appeared to be related to factors other than uremia (anoxia and impending death). Indeed, in one patient whose non-protein nitrogen level reached 240 mgs.%, the sensorium remained remarkably clear until the end.

The blood pressure has proven to be of interest in cases which exhibit renal failure and subsequently show the microscopic changes of pigment nephropathy. In 12 cases, one or more postoperative blood pressure readings are available; in five (41.6%) cases the level varied from 140/80 to 178/120. The highest readings tended to occur on the 3rd. postoperative day and fell somewhat if the patient lived longer. It is important that in only one case did the postoperative blood pressure remain at excessively low levels; this patient died of diffuse peritonitis only eleven hours after long-delayed surgery. In all other patients the blood pressure remained at levels which were above the accepted renal filtration pressure; two patients, however, did show systolic pressures in the range 90 - 100 mm. The predominant finding of normal or elevated blood pressure indicates that oliguria and pigment nephropathy are probably not the results of shock and hypotension during the postoperative period. Indeed, moderate hypertension may be indicative of renal difficulty even though the urine volume is not appreciably decreased as was observed in one case of this series.

Excluding the case which expired eleven hours after operation (peritonitis), the average duration of life after injury was 95 hours; the extremes were 34 and 184 hours. This relatively short period of survival indicates that factors other than uremia play a considerable part in death. Pulmonary edema, often severe, was observed in nearly all cases at autopsy. Furthermore, significant engorgement and dilation of the right side of the heart were observed with considerable frequency; in three cases (19%) this finding plus pulmonary edema appeared to be the direct cause of death. Thus pulmonary edema, with or without signs of right ventricular failure, closely parallels the finding of pigment nephropathy at autopsy. This appears to be related to disturbances in fluid balance which are secondary to renal decompensation as well as to "uremic pneumonitis" ("hyalin" membrane lining the respiratory bronchioles and alveoli and infiltration of the alveolar septa by inflammatory cells) which was observed in two cases. During the postoperative

* Oliguria - urinary output of 100 - 600 cc daily
Anuria - urinary output of less than 100 cc for any single 24 hour period.

period most patients received sufficient quantities of blood and plasma to prevent a significant fall in plasma protein concentration; hypoproteinemia is probably not, therefore a primary factor in the production of pulmonary edema. In 19 fatal cases who had anuria or oliguria the average blood volume was increased significantly (19.6 ± 4.3%) due to the presence of a true hydremia, and the maximum increase occurred at the time of greatest nitrogen retention in those patients in which recovery diuresis occurred[2]. In several instances relief has been obtained from pulmonary edema through the use of phlebotomy. Positive pressure oxygen inhalation was not used in an attempt to control pulmonary edema since means were not generally available for carrying out such therapy.

The importance of infection in decreasing the survival time is indicated by the fact that 11 cases (69%) had severe infection (diffuse peritonitis, anaerobic myositis, bronchopneumonis, multiple lung abscesses, and retroperitoneal cellulitis). Severe infection appeared to be related to a failure of the patient to exhibit hypertension prior to death.

The urine in patients with pigment nephropathy characteristically showed a low specific gravity; albuminuria and microscopic hematuria were present at some time in many cases. Hemoglobinuria was recorded in only one case but a dark colored urine was characteristically observed. Failure to observe pigment in the urine in these cases depends upon the fact that benzidine was not generally available. Through the use of the benzidine test it has been found that all patients who show pigment nephropathy at autopsy excrete hemoglobin. Other workers[2] have shown that the excretion of a "benzidine-positive" pigment is a constant finding in patients who subsequently show the microscopic lesion of pigment nephropathy.

Gross hemoglobinemia was observed in only two cases; thus the serum pigment concentration level is not commonly sufficient to be detected with the naked eye. However, Board[1] data show that a distinct rise occurs in the level of iron-protein pigments in the serums of many seriously wounded patients. Furthermore, the level tends to be higher and reach a peak sooner in those patients who showed pigment nephropathy at autopsy. Clinical jaundice was noted in three cases (19%) in our series.

In summary, pigment nephropathy is most common in patients with severe shock who respond poorly to replacement therapy so that large quantities of plasma and blood must be administered to accomplish resuscitation. Oliguria or anuria during the immediate postoperative period is the most helpful clinical evidence of renal failure, which is very insidious in its onset. There is a distinct tendency for such patients to develop hypertension, particularly if death does not occur until after the third post-operative day. In the presence of severe infection, however, a rise in the blood pressure is unusual. Infection and severity of trauma may likewise be responsible for death before the usual clinical picture of uremia becomes manifest.

Post-Traumatic Renal Failure (contd)

SOURCES OF URINARY PIGMENT IN PIGMENT NEPHROPATHY

The possible sources of the pigment which appears in the urine and is precipitated in the renal tubules will be discussed. It has been stated[3,4] that this pigment is acid hematin or a closely related iron-protein compound. It is helpful to consider the source of such pigment according to the following outline:

1. Hemoglobin derived from transfused erythrocytes.
   a. Hemolysis due to the transfusion of mismatched blood.
   b. Free hemoglobin present in banked blood.
      (1) Excessive age of blood.
      (2) Exposure of blood to extremes of temperature.
      (3) Excessive trauma (agitation) to blood.
2. Hemoglobin derived from the erythrocytes of the patient.
   a. Hemolysis due to massive transfusion of group O blood.
   b. Hemolysis resulting from burns.
   c. Hemolysis and breakdown of extravasated blood.
   d. Hemolysis due to Clostridial infection.
3. Pigment derivatives of myohemoglobin and cytochrome breakdown.
   a. Ischemic necrosis of muscle.
   b. Anaerobic myositis, (gas gangrene).

<u>Hemolysis due to Transfusion of Mismatched Blood.</u>

Severe hemolytic reactions have occurred very infrequently - in our experience only one such case has been encountered. In this case there was dyspnea, substernal pain, apprehension and lumbar pain which occurred early in transfusion and cleared upon discontinuance of the flow of blood. The practical absence of such reactions reflects credit upon the procedures employed in the selection of group O donors in the blood bank. The provision of group A and B banked blood would probably result in an increased number of this type of reaction during busy periods because of the possibility of giving incompatible blood. All patients have been re-typed and cross-matched unless profound shock necessitated immediate transfusion.

Post-Traumatic Renal Failure. (Hemolysis due to Transfusion of Mismatched Blood, condt)

During the administration of blood, chills have been observed in a small number of cases. In such patients we have routinely searched for the presence of free hemoglobin in the serum but in no instance has this been observed. We believe, therefore, that the vast majority of such febrile reactions are due to pyrogenic substances in the transfusion equipment. However, in the interest of safety, we have routinely changed to another flask of blood when a chill was observed. In this respect it is well to remember that the maintenance of transfusion equipment which is free from pyrogenic substances requires constant attention to detail in all installations and is apt to be particularlv difficult in the Field Hospitals.

Free Hemoglobin in Banked Blood.

It is obvious that blood must be carefully protected from conditions which increase the break-down of erythrocytes; it should be administered as soon after donation as is practically possible to prevent the inevitable deterioration which occurs as the blood grows older. The time limitation upon banked blood has varied considerably - from seven days (Fifth Army) to twenty days (ETOUSA - blood from the Z of I). The permission of longer time intervals has not been optimal, rather it has been exigent to the necessity for transporting blood extreme distances. It is our unproven impression that the incidence of renal complications has been higher when blood over ten days old has been used.

Blood deserves the greatest care in its preservation that is afforded any precious biological. It should be stored continually at four degrees Centigrade and remain under such conditions until shortly prior to its administration. Blood should not be warmed by artificial means preparatory to its administration. The agitation of blood during its distribution must be reduced to a minimum and blood flasks should never be shaken or inverted during handling in Field Hospitals. Such a policy diminishes the destruction of erythrocytes and allows one to judge the presence of hemolysis by inspection of the supernatant plasma.

It appears that the patient who is in shock is especially liable to renal damage during the process of pigment excretion due to such factors as reduced renal blood flow and acidosis. Under such conditions relatively low plasma concentrations of free hemoglobin appear to be able to cause disproportionate renal damage. Therefore it is imperative that even slightly hemolyzed blood not be given to such patients. All flasks of blood should be inspected for evidence of hemolysis; if this cannot be satisfactorily determined a sample of blood should be removed with a dry syringe under sterile precaution and the plasma of the centrifuged specimen observed for evidence of hemolysis. It should be remembered that bacterial contamination may result in pronounced hemolysis regardless of the age of the blood.

Post-Traumatic Renal Failure. (Sources of Urinary Pigment in Pigment Nephropathy, contd).

Hemolysis due to Massive Transfusion of Group O Blood.

It has been noted that the almost exclusive use of group O blood has resulted in a negligible incidence of major hemolytic reactions in forward hospitals. Such usage, however, admits the dangers inherent in the transfusion of group O blood to patients belonging to groups A, B, and AB. The realization of this danger has led to the titration of plasma agglutinins so that banked blood falls into two categories: (1) that in which the iso-agglutinin concentration is low (not active beyond a dilution of 1 : 64) and (2) blood whose agglutinin titer is high (active beyond a dilution of 1 : 64). These groups are referred to, respectively, as "low-titer group O blood" and "high-titer group O blood". Only the former was to be given to patients who did not fall into group O.

This program of agglutinin titration is based upon previous clinical experience. Further observations in this theater have shown conclusively that severe hemolytic reactions may result during transfusion of group O blood into a patient belonging to another group if the concentration of agglutinins in the transfused blood is excessively high. In another case "anti-A" agglutinins were demonstrable in the serum of a Group AB patient during a hemolytic episode which followed a series of transfusions with un-titered group O blood[2]. All evidence supports the fact that group O blood employed as a "universal donor" is potentially dangerous, and that agglutinin titration affords additional safety in such usage. In this respect, our first case of pigment nephrosis (severe) was observed following the administration of only 1500 cc. of untitered group O blood (the patient belonged to group B).

In the treatment of severe shock the agglutinin titer is of especial importance because of the fact that the frequent use of large quantities of blood may greatly reduce the usual dilution of transfused agglutinins. In other words, as the volume of transfused plasma approaches the plasma volume of the patient, the cells of the patient become progressively more liable to agglutination and hemolysis by virtue of the fact that the concentration of infused antibodies reaches an effective concentration in the plasma of the patient. This does not imply, however, that a strict parallelism exists between <u>in vitro</u> agglutinin titers and intravascular hemolysis; it is probable that under given conditions (in which the agglutinin titer, volume of transfused plasma and plasma volume of the patient are known) the ultimate agglutinin concentration in the blood of the patient will be considerably less than would be predicted by the factor of dilution. Evidence for this fact is indicated in the work of Thalhimer and Taylor[5], who prepared plasma pools from group O blood in which anti-A and anti-B agglutinin titers ranged up to 1 : 256. No reactions were observed from the administration of as much as 500 cc. of such plasma. Furthermore, a great many patients not belonging to group O have received 2000 - 2500 cc. of group O blood (low-titer) without adverse effects.

Post-Traumatic Renal Failure. (Sources of Urinary Pigment in Pigment Nephropathy, contd).

It is important to bear in mind that the intravascular hemolysis which may attend massive group O blood transfusions is very insidious from a clinical standpoint - most often there is no immediate clinical evidence of difficulty. It may be that hemolysis tends to occur late in anesthesia when the volume of transfused blood is highest and the ordinary clinical signs do not appear. However, we have not been able to demonstrate free hemoglobin in the serum of such patients as frequently as would have been expected. This is somewhat disturbing if we are to assume that the accepted renal threshold levels for hemoglobin (100 mgs. %) is correct[4]. The threshold may, however, be lower in the presence of shock.

In an attempt to minimize the reactions in the use of group O blood the following factors should be considered. Of greatest importance is the use of the least effective amount of such blood. From a practical standpoint this is best obtained by reducing blood loss as much as possible during the pre-operative and operative period. When intelligent use of tourniquets, splints and pressure dressing fail to control hemorrhage adequately, early operative control of hemorrhage is indicated. In this respect the gross total blood lost and the need for replacement therapy will be reduced. Likewise, transfusions at an ineffectual rate, particularly in the presence of continuing hemorrhage, tends to favor the administration of excessive quantities of blood - often with poor response to therapy.

Under ideal conditions, a patient not belonging to group O should not be given more than 1000 - 1500 cc's. of "low-titer" group O blood; subsequent therapy should consist of type-specific blood which has been carefully cross-matched. When possible, this has been carried out. However, during busy periods this has proved to be very difficult since it entails the expenditure of a great deal of time in cross-matching and drawing blood from locally available donors. It has been expedient to use the least effective amount of replacement therapy before and during operation and attempt to provide type-specific blood during the early post-operative period.

Study of agglutinin-titer in plasma pools by Thalhimer and Taylor[5] indicates a large margin of safety in the use of this agent in patients of all blood types. They found in the plasma pools studied that 99.7% had agglutinin titers (anti-A and anti-B) of less than 1:40 in 97% the titers were less than 1:20. However, pools were prepared entirely of type O plasma to secure pools with the highest possible titers. In these pools the titer ranged up to 1:256 and patients tolerated 500 cc. transfusions of such plasma without evidence of intravascular hemolysis. Instances are recorded in which the ill-advised administration of 2500-3500 cc. of plasma may well have exceeded even the safety factor of the

pooled plasma of relatively low titer. However, no proof is available that pigment nephropathy has resulted from the administration of plasma alone. Obviously such proof is difficult because all patients receive blood in addition to plasma.

Hemolysis Due to Burns.

One of our cases suffered from severe burns and it was noted by the microscopist that the renal changes associated with burns were indistinguishable from those seen in transfusion reactions. Presumably erythrocyte breakdown occurs in vessels adjacent to the burned area and free hemoglobin is released into the plasma[6].

Hemolysis and Breakdown of Extravasated Blood.

An increase in the serum bilirubin concentration and jaundice may follow pulmonary infarction or massive hematomata. Whether such conditions increase the concentration of iron-protein pigments in the blood is not known.

Hemolysis Due to Clostridial Infections.

The active hemolysis of erythrocytes by Clostridia has long been recognized. One of our patients exhibited marked hemoglobinemia - upon admission he suffered from a right hemothorax that was contaminated by these organisms. In two additional cases severe anaerobic myositis was present. An exact evaluation of the influence of infection in these instances is difficult because of the presence of other factors which may have been of equal or greater importance.

Ischemic Necrosis of Muscle.

Bywaters reports[4] renal changes following crushing injury which are indistinguishable histologically from those observed following transfusion reactions. From his work he concluded that the pigment casts (acid hematin) were due to the breakdown of myohemoglobin (muscle hemoglobin, myoglobin) as the result of prolonged ischemia in a limb compressed by debris. Necrotic muscle was analyzed for pigment and was found to have lost 75 % of the normal amount. The author states that similar changes may occur when trauma to a vessel interrupts the blood supply to an extremity but experience with this sort of wound was limited.

This report has stimulated considerable interest in the possibility that myohemoglobin may be responsible for the deposition of pigment in the nephron of those patients who wounds result in ischemia of large muscle groups. In five cases (31%) significant ischemia of muscle was present; but again, transfusion therapy was employed in all and

Post- Traumatic Renal Failure. (Sources of Urinary Pigment In Pigment Nephropathy, contd).

Clostridial infection was an additional factor in one case. Probably partial return of circulation to involved muscle is an important factor.

The molecular weight of myohemoglobin is approximately 16,700 (hemoglobin 68,000) and its renal clearance is twenty-five times as great as hemoglobin[4]. This fact is believed to explain partially the failure to observe evidence of hemolysis in the plasma of patients suffering from crushing injuries. Presumably myohemoglobin is rapidly passed into the glomerular filtrate to be precipitated in the form of acid hematin in the acid urine of the renal collecting tubules.

Such an hypothesis is inviting and would explain our failure to find evidence of hemolysis in the serum of most patients as well as partially explain the observation of hemoglobinuric nephropathy in group O recipients. More detailed studies indicate that myoglobin excretion may be markedly increased in certain severely wounded man; this affords an important step in our understanding of the renal lesion which may follow trauma[2].

Anerobic Myositis.

Presumably, the presence of Clostridial infection may favor the release of myohemoglobin and heme-containing compounds from the cytochromes. However, very little is known in relation to such factors.

It is apparent that many complex factors are involved in the precipitation of pigment casts in the lower nephron. The highly acid urine observed in shock is believed to favor the conversion of excreted hemoglobin into insoluble acid hematin. This concept forms the basis of alkalinization (sodium citrate, sodium bicarbonate) therapy in an attempt to prevent pigment deposition in the collecting tubules. In our experience this has proved to be disappointing in preventing renal damage, or in bringing about an alkaline diuresis. One explanation for this appears to lie in the fact that renal changes occur very early (as early as 11 hours and 23 hours after surgery, in our series) and once these have occurred, no amount of alkali therapy will prove effective. In a considerable number of instances we have routinely carried out alkalinization in the immediate postoperative period when more than 1500 cc's. of blood were administered to a patient not belonging to group O. In the absence of abdominal wounds, sodium bicarbonate has been given by Levin tube in the shock ward in several instances. This appears to have been worthwhile, particularly in severe extremity wounds, but accurate evaluation is difficult. The stomach is drained via the indwelling tube just prior to the induction of anesthesia.

Surgery is indispensable in the control of conditions which favor the release of myohemoglobin through destruction, ischemia and infection

of muscle. It may be that amputation of a badly damaged and ischemic limb is very important in preventing the absorption of muscle pigment and may account for the fact that those cases requiring amputation may make an uneventful recovery following very large transfusions.

SUMMARY AND CONCLUSIONS

1. A study has been made of 330 fatal cases caused by intra-abdominal injury to determine the incidence of oliguria and anuria.

2. A clinicopathological analysis of sixteen proven cases of pigment nephropathy is presented.

3. The origin of the pigment which is excreted in all proven cases of pigment nephropathy is discussed, particularly in relation to transfusion therapy, type of trauma and certain types of infection.

The suppression of urinary excretion which occurs in shock does not usually persist for an appreciable period after shock has been relieved. However, severe shock, particularly if prolonged, appears to be capable of producting serious impairment of renal function the manifestations of which persist after resuscitation has been effected. The persisting renal failure being preceded by oliguria, is insidious in its onset and occurs relatively soon after injury.

Post-traumatic renal failure occurs predominantly in those patients who suffer severe injuries and in whom shock is severe or prolonged. In the severely wounded who exhibit renal failure the characteristic lesion of pigment nephropathy is commonly found. If pigment excretion is marked, as after transfusion of incompatible blood, renal failure usually results without antecedent shock. If shock is of sufficient severity or duration it may alone produce irreparable kidney damage. Often the two factors of shock and pigment excretion co-exist. Evidence indicates that the kidney, because of marked renal vasoconstriction, may surpass even the brain in its susceptibility to the decreased blood flow and anoxia of severe shock.

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XII

DEATHS IN FORWARD HOSPITALS

DEATHS IN FORWARD HOSPITALS

This report is a general statistical report of 1165 fatal cases occurring in forward hospitals in the combat zones of the North African, Mediterranean, and European Theaters of Operations and covers the period from November 1942 to May 1945. The cases tabulated were limited to those which died in the forward hospitals, and were classified almost exclusively as priority or non-transportable. All cases were obtained from the records of the 2nd Auxiliary Surgical Group and all cases were treated by members of this Group. This report however is in no way a mortality rate report for the Group as it does not include the cases dying after evacuation to the rear area hospitals. These cases represent 5.6% of all the cases done by this Group. With the exception of most of the neuro-surgical cases and a few other priority cases, the patients were seen and treated in forward first priority surgical hospitals (platoons of a Field Hospital). The hospitals in which these cases were treated were:

TABLE I

Hospitals In Which 1165 Fatal Priority Cases were Treated

Field Hospital Platoons....................	986 Cases
Evacuation Hospitals.......................	161 Cases
Forward Hospitals (type not stated)........	18 Cases

As this series covers all cases in the priority group, some civilian and prisoner of war patients are included. The ages of the patients varied from two to 78 years of age with an average of 25.4 years. Practically all cases had reached a fatal termination within 10 days of their operation, only four and one tenths percent living longer than this time. Nineteen (one and six tenths percent) cases died in the shock ward shortly after admission, twelve (one percent) cases during the induction of the anesthesia, 85 (seven and three tenths percent) cases during the operation and 678 (49.7%) cases within the first 24 hours postoperatively.

PRIOR TREATMENT AND SHOCK

No accurate record could be obtained on the use of chemotherapy prior to entry to the Field Hospital; however, all cases had their wounds dusted with sulfanilamide crystals. Splints, tourniquets, etc.,

Deaths in Forward Hospitals (Prior Treatment and Shock, cont'd).

were used where needed and sedation had practically always been given. Varying amounts of plasma had been given to these patients in the forward medical echelons to combat shock, whole blood usually not being available to the medical installations in front of the Field Hospitals, but the majority of patients were in some degree of shock when they reached these hospitals.

In the early days of the war the management of shock was not well understood, nor was the treatment adequate in most cases. Usually the surgeon either spent a certain amount of time in the shock ward or he directed the shock treatment of one patient while operating on another, a system which did not work for the best advantage of the patient. Also, the supply of whole blood was very low, the only source being the hospital personnel and this was quickly exhausted during the rush periods. The surgeon often had insufficient time to draw and administer the blood after he had found a compatible donor. The following two brief case reports bring out the inadequacy of the shock treatment during this early part of the war.

Case No. 1. This patient entered the hospital with an abdominal wound but was in fairly good shape. B.P. 110/60, Pulse 100, Respiration 20. With thestart of the operation the patient began to go into shock (B.P. and pulse not reported) and steadily grew worse. Seventy minutes after starting the operation he received one unit of plasma and at 85 minutes he was started on one unit of blood. The operation was terminated at 90 minutes because of the patient's poor condition and he died a short time later. This patient received no preoperative blood or plasma.

Case No. 2. This patient also had a severe abdominal wound but was in severe shock on entry to the hospital (BP and Pulse not stated). During the first six hours in the shock ward he received two units of blood, during the seventh hour, nothing, and during the eighth hour, eight units of plasma and then was operated on, the patient dying during the operation.

With the beginning of the Italian Campaign the problem of shock became better understood and specific shock teams were utilized with greater efficiency. Also blood banks began to form, first in November and December 1943 in the forward hospitals in Italy which drew blood daily from the surrounding service troops. In the first part of 1944, organized blood banks in the rear areas started supplying the forward hospitals with unlimited amounts of blood, and by the middle of 1944 the system was working very efficiently.

Deaths in Forward Hospitals (Prior Treatment and Shock, cont'd).

In order to bring out the change of shock treatment brought about by the blood banks, and by the use of regular shock teams and also the changing ideas on the relative value of the use of plasma and whole blood, the European war was divided arbitrarily into six different campaigns. Unfortunately the surgical teams were not particularly used for priority surgery nor were the hospitals always close to the front, and records were lost or inadequate during the Tunisian Campaign, so the total number of cases for this period is small. The number of cases for the Sicilian Campaign is also very small because of the short duration of the campaign, the smaller number of forces committed to action, and the lower number of casualties, of which only about 8% were priority cases. It was however, in this campaign that surgical teams and Field Hospital platoons first started working in the forward areas with the Clearing Stations. The following tables show the use of dried plasma and whole blood in units per patient for these campaigns. One unit of plasma was 250 c.c. of mixed plasma, and a unit of blood, 500 c.c. of whole blood.

TABLE II

Units of Plasma Per Patient Used in Different Campaigns

Campaigns	No. Cases	In Bn Aid Stat. and Med. Bn.	In Field Hospitals Pre-op.	In Field Hospitals During Op.
Tunisian	28	.46	2.23	.16
Sicilian	17	1.00	2.54	.38
Italian (Sept-Dec 43)	194	1.48	2.03	.82
Italian (Jan-June 44)	380	1.43	1.25	.62
Italian and Southern France (July-Dec 44)	415	1.69	1.31	.87
Italian and Germany (Jan-May 45)	131	1.97	1.25	.75

Deaths in Forward Hospitals (Prior Treatment and Shock, cont'd).

TABLE III

Units of Blood Per Patient Used in Different Campaigns

Campaign	No. Cases	Units of Blood Per Patient In Field Hospitals Pre-op.	During Op.
Tunisian	28	.15	.05
Sicilian	17	.92	.23
Italian (Sept-Dec 43)	194	1.31	.79
Italian (Jan-June 44)	380	1.87	1.71
Italian and Southern France (July-Dec 44)	415	2.16	2.33
Italian and Germany (Jan-May 45)	131	3.33	2.24

It is seen at once that the use of plasma in the past one and one-half years has become fairly well stabilized and that its use as a restorative preoperatively has fallen off greatly. The use of whole blood before and during operation shows a marked and steady increase in the amount used up to the end of the war. These figures do not mean that all patients received four and one half to five and one half units of whole blood in the Field Hospitals during the past year, but that this amount was given to those patients included in this series who were as a rule, the most seriously wounded patients entering the Field Hospitals.

In determining the degree of shock in these cases, all available information was utilized, the blood pressure and pulse reading, the opinion of the surgeon, the type and amount of restorative therapy used and the response of the patient to these measures. Using these criteria for determining the degree of shock these fatal priority cases fell into the following groups on admission to the Field Hospitals:

TABLE IV

Type and Frequency of Shock On Entry

No or Mild Shock.............	20.4%
Moderate Shock...............	17.6%
Severe Shock.................	62.0%

Deaths in Forward Hospitals (Prior Treatment and Shock, cont'd)

It is seen from Table IV that about 80% of these patients enter the hospital in moderate to severe shock. Also, this syndrome is the biggest single cause for death, it being the principal cause for death in 41.4% and the contributing cause in 10.1% of the known deaths in this series.

Shock in battle casualties of the type of cases in this series was considered due to trauma, contamination, hemorrhage or some combination of these three causes. Cardio-respiratory failure is also a strong cause for shock, but unfortunately, the records were not adequate enough to determine the presence of this syndrome. The cases dying either primarily or secondarily of shock due to hemorrhage were listed under hemorrhage, the cases dying of shock due to contamination, trauma or a combination of the three were all grouped under the term shock (See Tables). An attempt was made to find the basis for the shock in these cases according to the evidence presented by their case records. In most cases, reason for the shock was evident, but in some cases an opinion had to be made after reading the record over completely. In practically all cases there were two or three of these causes for shock present, but they were listed according to which was obviously exerting the most influence. For example, a case in shock with a lacerated colon and much fecal spilling has elements of both trauma and hemorrhage, but the contamination of the peritoneal cavity by feces was considered to be the primary reason for the shock, provided, of course, that there was not excessive trauma or bleeding. The cases which could not be fitted into these single groups were placed in combination groups.

TABLE V

Causes for Shock*

Type Of Case	Trauma	Contamination	Hemorrhage	Hemorrhage and Trauma	Trauma and Contamination	Contamination and Hemorrhage
Thoraco-abdominal	17%	21.5%	17%	12%	21.5%	11%
Thoracic	57.5%		32.5%	7.5%	2.5%	
Abdominal	6%	41.5%	16.5%	4%	18%	14%
Extremity	72%	2%	10%	14%	2%	
Neck			100%			
Burns	100%					
Average	23%	27.5%	18.5%	7.5%	14%	9.5%

*Cardio-respiratory failure as a cause for shock not included as this could not be determined accurately from the case records.

Deaths in Forward Hospitals (Prior Treatment and Shock, cont'd).

Table V gives a rough idea of the type of shock encountered in these priority cases. These figures were obtained from only those cases dying primarily of shock.

TIME INTERVAL

Because of the lack of data on many charts, the only accurate information was obtained for the period from the time of injury to that of operation.

Thirty-six percent of the cases in this series had a time lag of over 12 hours. The following complications were noted either on entry or at operation in this latter group of patients.

TABLE VI

Complications Associated With Prolonged Time Lag

Time Interval	Severe Shock	Established peritonitis	Anaerobic Infection	Generalized Wound Infection	Meningitis	No Apparent Complications
12 - 24 hours	56%	18%	8%	3%	1%	28%
24 - 36 hours	50%	25%	10%	4%	0	28%
36 and over	34%	18%	13%	7%	2%	29%

Theoretically, most abdominal injuries have peritonitis but only those cases with a notation of marked peritoneal reaction (exudate and fibrin formation) were counted for the above figure.

It is interesting to note that the various infections (except peritonitis) show a steady increase in frequency with the increasing time interval as would be expected. The drop in the percentages of those cases with the longer time interval entering the hospitals with severe shock and peritonitis is probably due to the fact that the very seriously wounded die in the field within 12 to 36 hours when treatment is not available. The same argument may be true for those patients who do not have one of these complications on entry. (See last column of above table).

Deaths in Forward Hospitals.

ANESTHESIA

Most cases were graded prior to surgery as to their risk, risk 4 being the most serious cases. Fifty-three per cent were risk 4, 29.4% rick 3, 16% risk 2, and one and onetenths percent risk 1. Practically all cases were seen preoperatively by the anesthetist and the anesthesia was decided upon in consultation with the surgeon. Pre-medication consisted mainly of atropine sulfate, usually given intra-venously, as the patients had already received large doses of morphine in the forward area. In 28 cases there was actually some element of morphine intexication which contributed a distinct hazard to the course of the case, some patients arriving at the hospital in coma and with markedly depressed respirations, in one case 6-8 respirations per minute. Nineteen cases died in the shock tent and 12 cases died during the induction of the anesthesia. In 1040 cases the following types of anesthesia were used:

TABLE VII

Type of Anesthesia Used in 1040 Fatal Priority Cases

Anesthesia	Thoraco-Abdominal	Thoracic	Abdominal	Extremity	Head & Spine	Neck	Total
Ether & Nitrous-Oxide Oxygen (Endo-tracheal)	194	66	385	95	6	6	752
Ether Closed System	2	11	3				16
Pentothal Sodium		8	1	13	14		36
Ether Open Drop	16	7	100	59	2	1	185
Local	3	6	1		32	5	47
Spinal			1	1			2
Chloroform			1				1
Ethyl Chloride			1				1

Deaths in Forward Hospitals (Anesthesia, cont'd).

The duration of the operations in 802 cases were as follows:

TABLE VIII

Duration of Operation

Minutes			
0 - 60	60 - 120	120 - 180	180 and over
14.9%	35.8%	30.3%	19%

In 18 (1.6%) cases, the deaths were directly attributed to anesthetic complications. Four deaths occurred during the induction of the anesthesia, seven during the operation, and seven postoperatively. The anesthetic agents used in these fatal cases were gas-oxygen-ether endotracheal seven, pentothal five, ether open-drop four, ethyl chloride one, and in one case the agent was not stated. In twelve cases, the death was due to the aspiration of vomitus, two during induction of the anesthesia and five each during and after operation. In one case, the vomiting was precipitated by the surgeon trying to introduce a Levin tube with the patient still under anesthesia. In another case the endotracheal tube was undoubtedly in the esophagus for when positive pressure was applied, the stomach was seen to enlarge and before any corrective measures could be applied, the patient vomited profusely and died an asphyxial death. An autopsy of the abdomen revealed an air and fluid filled stomach of tremendous proportions. The agents used in these cases were gas-oxygen-ether five, ether open-drop four, pentothal two, and unknown one. In one case the patient died during a pentothal anesthesia, but the record was incomplete and no explanation of the death was noted. The following brief case reports are of the five remaining cases of deaths due to anesthetic complications.

Case 3. This 20 year old soldier had wounds of both lower legs and thighs. He received morphine tartrate gr. 1/4 but no atropine preoperatively and was operated on 39 hours after injury under pentothal sodium anesthesia. His general condition was good on entry and during the 70 minute operation (B.P. 130/78, Pulse 88, respirations 18 preoperatively). Thirty minutes after operation he was found dead. Autopsy revealed much mucus in the tracheo-bronchial tree with plugging of the bronchi.

Case 4. This 22 year old soldier had wounds of the abdominal wall and a compound fracture of the femur. He had received morphine

Deaths in Forward Hospitals (Anesthesia, cont'd).

tartrate gr. 1/4 and two units of plasma before entry and was in clinical shock on entry. B.P. 160/68, pulse 152, respirations 24. He was given one unit of blood and atropine sulfate gr. 1/100, and then operated upon under gas-oxygen-ether endotracheal anesthesia 60 hours after his injury. The abdomen was found to be negative and upon closure of the peritoneum he suddenly stopped breathing. Bronchoscopy revealed copious amounts of thick yellow mucus which could not be removed quickly enough to prevent his death. Autopsy revealed the bronchial tree and lungs to be filled with this thick yellow secretion.

Case 5. This soldier entered the hospital in severe shock with a right thoraco-abdominal injury. He responded well to shock therapy and continued to do well during the 100 minute operation under ether endotracheal anesthesia. Four hours after operation, he was found in marked respiratory difficulty due to obstruction of his airway by his tongue. This was immediately corrected, but he died almost at the same time.

Case 6. This patient arrived in moderate shock after having received nine units of plasma and morphine tartrate gr. 1/2 in the forward medical installations. He had qounds of his right arm and abdomen. Nine hours after injury and after he had received two units of blood and two of plasma, the anesthesia was started (B.P. 110/60, pulse 160, respirations 20) using ethyl chloride for induction. When he reached the first plane of the third stage of anesthesia his respirations became irregular and stopped in spite of oxygen, coramine and epinephrine. The opinion was that he died of ventricular fibrillation.

Case 7. This 23 year old soldier had one small wound in the left popliteal space with a lacerated popliteal artery and vein. He was admitted 11 hours after injury in severe shock and with markedly depressed respirations. In the 90 minutes prior to entry this patient had received four units of plasma, Morphine tartrate gr. 1 1/2. He was treated for two to three hours and responded well from his shock and over-morphinization. Five minutes after starting the pentothal anesthesia his pulse became markedly irregular and he expired in spite of supportive measures. The opinion was that he died of ventricular fibrillation.

All anesthetic complications are not included. There were several cases of postoperative atelectasis and pneumonia but the records were not complete enough for accurate analysis.

Most of the complications listed above occurred in the early phases of the war. Most of the cases during the early period received open drop ether anesthesia without preliminary gastric aspiration, and

bronchoscopy was seldom done. During the latter part of the war gastric aspiration was done on all cases, the patient entering the operating tent with the stomach tube in place, and endotracheal anesthesia was almost routinely used. Furthermore, bronchoscopies were done when indicated.

WOUNDING AGENTS

The causative agent in many of these cases was not stated and in many cases where it was stated, the specific type of missile was not noted, most cases being simply high explosive fragments. However for 1093 cases the following missiles were given:

TABLE IX

Type of Missile

High Explosives	809	Cases	74%
Shell Fragments (unclassified)	692	"	
Mortar fragments	32	"	
Mines	40	"	
Bombs	31	"	
Booby traps	3	"	
Hand grenades	10	"	
Rifle grenades	1	"	
Small arms	254	Cases	23.2%
Gunshot (unclassified)	218	"	
Machine gun	32	"	
Machine pistols	4	"	
Missiles other than above	30	Cases	2.7%
Knife	2	"	
Burns	8	"	
Rocks	1	"	
Tree stump	1	"	
Blast	1	"	
Accidents	17	"	

TYPES OF CASES AND NUMBER OF INJURIES

In order to better study these cases as to their cause of death, they were divided into nine different groups according to the type of their major injury. In the majority of cases the group in which the

Deaths in Forward Hospitals (Types of Cases and Number of Injuries, cont'd).

case belonged was self evident. In some however, there was a question as to the group in which the case properly belonged. Where the case had two or more different types of injury an opinion was made on the evidence in the case record as to which injury seemed to be the most serious at the time of operation, and the case was placed with the corresponding group. Roughly, 42% of these fatal cases had one or more complicating injuries aside from that of the group in which the case was placed. The following table shows the grouping of the cases in this series of 1165 deaths. One case of this series had no wound but suffered from a severe blast injury, particularly to his brain and lungs, as proven by autopsy.

TABLE X

Type of Major Injury in 1165 Fatal Priority Cases

Type of Injury	No. Cases	No. Dying in Shock Ward	No. Dying During Induction of Anes.	No. Dying During Operation	No. Dying After Operation
Thoraco-Abdominal	238	5	0	24	209
Thoracic	98	1	1	11	85
Abdominal	534	6	6	39	483
Extremity	191	4	5	8	179
Head	62	2	0	1	59
Spine	8	0	0	0	8
Neck	18	1	0	1	16
Maxillo-facial	7	0	0	1	6
Burns	8	0	0	0	8
Blast Injury	1	0	0	0	1
TOTAL	1165	19 (1.6%)	12 (1.0%)	85 (7.3%)	1049 (90.1%)

Nineteen cases in this series died in the shock tent before they could be prepared for surgery. This figure in no way indicates the total number of cases dying in Field Hospitals before surgery. During the major portion of the time the shock teams were made up from Field Hospital personnel and their records are not included in this series. Only those records on cases which were treated by members of the Auxiliary Surgical Group were available. Twelve cases died during the induction of the anesthesia and 85 cases during operation. These records cover all cases in these latter categories as all of these cases were cared for by this group.

Deaths in Forward Hospitals (Types of Cases and Number of Injuries, cont'd).

That these cases were of the priority group is further attested by the following table on the number of serious major injuries requiring operative intervention:

TABLE XI

Frequency of Major Injuries

Number of Major Injuries per Patient	Percentage of All Fatal Cases
1	21.3%
2	29.3%
3	26.2%
4	14.5%
5	5.2%
6 or more	3.5%

An attempt was made to determine the principal and one main contributing cause for death in each case. In somecases this was easily done, but in many cases, the problem of determining the causes of death was a difficult and unsatisfactory one. The records were often incomplete, giving no cause for death or only a contributing cause for death without the principal cause. Some records gave causes for death that did not seem to be related with the general course of the case as stated in the progress notes, or were not supported by autopsy findings. Examples are cases dying of pulmonary edema only or of renal failure within 24 to 48 hours of their operation. Seven hundred and seven (60.7%) of the cases in this series were autopsied. Only those cases dying on the operating table where the surgeon continued his exploration and those cases actually autopsied were included in this figure. Cases dying immediately after operation or later were not included unless a formal autopsy was done. Although 60.7% of the cases had some type of an autopsy, hardly any were complete, the autopsy being an exploration of the abdomen alone, chest alone, or a combination of both, in the majority of cases. Also very few autopsy records included microscopic reports. In only 10% of the cases recorded as dying of gas gangrene was there a conformation by smear or culture. Eighty percent of the cases dying of pulmonary embolism were however,recorded as having been found at autopsy. For allthe other cases the recorded clinical opinion was the only diagnosis available.

Deaths in Forward Hospitals (Types of Cases and Number of Injuries, cont'd).

In many cases, the principal cause for death was easily found but because of the multiplicity of serious injuries the main contributing cause of death could not be determined. There were also a few cases with more than one serious injury which did not have any apparent principal cause for death other than their wounds. For these two groups of patients the contributing and principal causes for death, respectively, were listed as "injuries". All cases in which either the principal or contributing cause, or both, could not be determined, were placed in the "unknown" category. (See Tables).

THORACO-ABDOMINAL INJURIES

In this series of 1165 cases, 238 (20.4%) were primarily thoraco-abdominal injuries. Five of these cases died in the shock ward shortly after their admission. Of the other cases, 131 (56.2%) were single thoraco-abdominal wounds and 96 (41.2%) were associated with other injuries. There were six cases which had bilateral thoraco-abdominal wounds without other complicating injuries. In 123 cases (52.8%) the thoraco-abdominal wound was on the left and in 104 (44.6%) on the right.

It is interesting to note that of 44 cases of small bowel injury, the duodenum was involved in 14 cases. Of 19 cases of small bowel injury in right thoraco-abdominal cases, the duodenum was injured in 11 cases (58%). However, of the six injuries to the inferior vena cava, five of them occurred in left thoraco-abdominal cases. The number of other visceral injuries follows roughly as would be expected from the side of injury. The number of injuries to the lungs is probably not correct as they were not always recorded, however in many cases the missile passed very low in the pleural cavity and did not injure the lung.

An abdominal approach was used in 39% of the recorded cases either alone or with a chest debridement or a thoracotomy incision. Of these abdominal approaches, 41 were in right, 50 in left and one in bilateral thoraco-abdominal cases.

In 127 cases living longer than 24 hours there were 76 recorded complications which did not immediately cause death but which materially hindered the progress of the case.

Deaths in Forward Hospitals (Thoraco-Abdominal Injuries, cont'd).

TABLE XII

Postoperative Complications in Thoraco-Abdominal Cases

	Number of Cases
Pulmonary edema	20
Pneumonia	15
Atelectasis	17
Jaundice	3
Anaerobic infection	4
Subphrenic abscess	1
Pressure pneumothorax	3
Cardiac failure	2
Gastric ulcer	1
Malaria	1
Duodenal fistula	1
Extensive hematoma and/or hemorrhage of the lung	8

Of the four cases of anaerobic infection, three occurred in left uncomplicated thoraco-abdominal wounds. In one case, the cardiac failure was in a patient with rheumatic heart disease (old). The duodenal fistula occurred in a case where the perforation was overlooked at the time of the operation.

On entry to the hospital 51% of these cases were in severe shock and in 42% of the cases it was the principal cause for death. Almost half (46%) of these fatal cases died within 24 hours of their operation (106 cases) or in the shock ward (five cases). It is interesting to note that of the six bilateral thoraco-abdominal cases, only two entered the hospital in severe clinical shock, three cases however died of shock due respectively to hemorrhage, severe contamination, and trauma and contamination. Of the other three cases one each died of pulmonary embolus on the sixth day, cardiac failure on the second day, and atelectasis on the day of operation. Of the cases dying of peritonitis, nine were associated with overlooked visceral perforations of the gastro-intestinal or genito-urinary tract.

Of the cases dying principally of shock it was found that 48% of the cases were with single thoraco-abdominal wounds while 34% were with thoraco-abdominal wounds with an associated injury.

One case died during bronchoscopy immediately postoperatively. This death was thought to be due to the vago-vagal reflex causing an

Deaths in Forward Hospitals (Thoraco-Abdominal Injuries, cont'd).

acute cardiac standstill.

Twenty-nine cases died before their immediate treatment could be carried out, five in the shock ward and 24 at some stage of the operation. The following table shows the causes for death as given for these early fatal cases.

TABLE XIII

Causes of Early Death in 29 Thoraco-Abdominal Cases

	In Shock Ward	During Operation
Shock		13
Hemorrhage	2	4
Injuries	0	1
Unknown	3	0
Ventricular fibrillation	0	2
Atelectasis	0	1
Aspiration of vomitus	0	1
Cardiac Tamponade	0	1
Vago-vagal syndrome during bronchoscopy	0	1
Infection, wound, general	0	0
Peritonitis	0	0

ABDOMINAL INJURIES

The largest single group of patients entering the forward Field Hospitals as priority patients are those with abdominal injuries. For this reason and also because usually the abdominal injuries are of a more serious nature the deaths associated with this injury roughly equal those from all other groups. In this series they make up 46% of all deaths in the forward hospitals.

Of 534 abdominal cases twelve cases died before any surgery could be done, 281 had abdominal injuries only and 253 cases had associated injuries as follows:

TABLE XIV

Associated Wounds in Abdominal Cases

	No. Cases
Extremity Wounds	168
Thoracic or chest wall wounds	28
Head wounds	11
Neurological wounds	11
Vascular wounds (other than abdominal)	44
Skeletal wounds (other than extremity)	14
Neck wounds	5

Deaths in Forward Hospitals (Abdominal Injuries, cont'd).

Of 411 cases recorded, 270 (65.7%) entered the hospital in severe shock and 65 (15.8%) in moderate shock. In 484 cases where the primary cause for death was noted, 45% were due to shock.

Fifty-one cases (9.5%) were in such poor condition that they died before a great deal could be done for them. In this latter group, 44 cases (86%) died primarily of shock. The following table lists the principal causes of death for these cases as given on the case records:

TABLE XV

Causes for Early death in 51 Abdominal Cases

	In Shock Ward	During Induction of Anesthesia	During Operation
Shock from Hemorrhage	4	2	11
Shock from trauma and/or contamination	1	2	24
Anaerobic infection			2
Anesthetic complication, aspiration of vomitus		1	
Anesthetic complication ventricular fibrillation		1	
Unknown	1		1
Injuries			1

The percentage of deaths due to peritonitis (14%) is high but it is due in part to the fact that in 17 cases perforations in the gastro-intestinal or genito-urinary tract were overlooked at operation. Correcting for this brings the rate to 10.6%. It was further noted that 16.5% of the cases in this series had a full blown, established peritonitis at the time of operation.

THORACIC INJURIES

There were 98 cases (8.4%) that were primarily chest injuries. Two cases died before surgery, one in the shock ward and one during the induction of the anesthesia. The causes of the death were not stated. Of the remaining cases, 58 were injuries to the chest only and 38 were chest injuries associated with other injuries. In six cases the chest injury was bilateral, two of which also had associated extremity wounds.

Deaths in Forward Hospitals (Thoracic Injuries, cont'd).

Of these 98 cases only 52 lived longer than 24 hours after operation and among these cases there were 31 postoperative complications recorded.

TABLE XVI

Postoperative Complications in Thoracic Cases

	No. of Cases
Atelectasis	8
Pneumonia	7
Pulmonary edema	10
Broncho-pleural fistula	3
Empyema	2
Malaria	1

Pulmonary edema, pneumonia and atelectasis complicated both thoracic and thoraco-abdominal cases with about the same frequency according to these figures.

TABLE XVII

Comparison of Thoracic Complications in Thoracic and Thoraco-abdominal Cases.

	Thoraco-Abdominal Cases	Thoracic Cases
Pulmonary edema	16%	19%
Pneumonia	12%	13%
Atelectasis	13%	15%

Fifty-seven percent of these cases entered the hospital in severe shock and 30% died of shock primarily within 24 hours of their operation. Five of the six cases of pulmonary embolus occurred in cases without associated injuries and in five cases the right chest was the side injured. In thoraco-abdominal cases however, this does not hold, the incidence of pulmonary embolus being fairly evenly distributed to all types of cases.

Eleven cases died during the operation. The following table lists the principal causes of death for these cases.

Deaths in Forward Hospitals (Thoracic Injuries, cont'd).

TABLE XVIII

Causes of Early Death in 11 Thoracic Cases

	Number of Cases
Shock due to trauma	4
Shock due to hemorrhage	1
Anesthetic complication aspiration of vomitus	2
Atelectasis, massive	1
Ventricular fibrillation	1
Cardiac tamponade	1
Blast injury to the lungs	1

EXTREMITY INJURIES

Sixteen percent (191) of these fatal cases were in patients that primarily had extremity injuries. A little over half of these cases (55.5%) had wounds involving the extremity only. The majority of associated wounds were minor in nature but in five cases there were associated abdominal injuries. In three cases an intra-abdominal wound was not suspected and perforations of the bladder, duodenum, and ileum were overlooked. In the fourth case there was a breakdown and leaking from a sigmoid suture line and in the fifth case there was a spontaneous perforation of the ileum in a small infarcted area of the bowel due to a severe blast injury. In four of these cases peritonitis was either a principal or contributing cause for death. Thirty-four cases suffered one wound only and 33 cases (17%) had only soft tissue wounds. In 149 cases there were 156 major fractures, 51 traumatic amputations and 41 major vascular injuries. Two cases had three traumatic amputations (both lower legs and one arm). There was no case reported in which parts of all extremities were amputated traumatically. Sixty-two per cent (62%) of these cases had one major injury and 36% had two (traumatic amputations and/or fractures).

Deaths in Forward Hospitals (Extremity Injuries, cont'd).

TABLE XIX

Type of Major Injuries in Extremity Cases

Fractures	No. Cases	Traumatic Amputations	No. Cases	Vascular Injuries	No. Cases
Femur	47	Upper leg	8	Common iliac A&V	1
Tibia & fibula	40	Lower leg	30	Femoral A&V	19
Foot and ankle	12	Foot	6	Popliteal A&V	7
Humerus	23	Upper arm	5	Axillary A&V	6
Radius & Ulna	7	Lower arm	2	Brachial A&V	8
Pelvis	18	Hand	0		
Scapula	5				

On entry, 58 % of these cases were in severe shock and 21% in moderate shock, and in 39% of the cases shock was the principal cause of death. An anaerobic infection accounted for 19% of the principal causes for death.

Nine cases died before reaching surgery, four in the shock ward and five during the induction of the anesthesia. Eight morecases died on the operating table at some stage of their operation. The following table lists the principal causes for death in these 17 cases:

TABLE XX

Principal Causes of Early Death in Nine Extremity Cases

Cause of Death	In Shock Ward	During Induction of Anes.	During Operation
Shock from trauma	1	1	5
Shock from hemorrhage		1	1
Unknown	3	1	1
Pulmonary embolus		1	
Ventricular fibrillation (?)		1 (Case 7, Page)	
Pentothal death (unexplained)			1

HEAD AND SPINE INJURIES

Roughly 5% (62 cases) of these fatal cases were primarily injuries of the head. Forty-five cases had head injuries alone and 17 were complicated by associated injuries. Although these cases were considered

Deaths in Forward Hospitals (Head and Spine Injuries, cont'd).

as priority cases they were not considered non-transportable unless the injury was extremely severe. It was found that these cases stood transportation better before their operation than after, so practically all cases were treated in the Evacuation Hospitals. Two cases reached the hospital in a moribund condition and died of very extensive cerebral damage in the shock ward shortly after arrival.

Twenty-two percent of these cases entered the hospital in severe shock while 71% had either none or very mild clinical shock. There was no case that died primarily of clinical shock. The majority of these cased (76.6%) died of extensive cerebral lacerations, mostly within the first 24 hours, only two patients living for five days. Either meningitis or infection of the head wound was the cause for death in 12.7%of the cases, the patients dying on the fourth to the 15th day. Only two cases died of causes not related to their head injury, one from a pulmonary embolus and the other from an anaerobic infection in the extremity wound.

Although there were 43 fractures of the spine with spinal cord trauma there were only eight cases (0.7%) in which it was the primary injury. Of these, three were in the cervical area (C6, C7; C6, C7; and T1), three in the dorsal area (D6,D7; D8,D9; and D10) and two in the lumbar area (L1 and L1 and L2). Two of these cases had minor extremity wounds, (D10 and L1). Two of the three cervical cases (C6 and C7) died a respiratory death within the first 24 hours and one case (D8) died of a severe blast injury to his lungs and abdomen. One case (D10) died on the day of his admission from shock, and one case (L1) on the third day from an anaerobic infection in the extremity wound. The other three cases lived from five to six days, but their causes of death were not stated.

All of the remaining 35 cases of spine and spinal cord injuries were in cases that had major injuries elsewhere and were classed with the other groups as follows:

TABLE XXI

Number of Cases With Cord Trauma Complicating the Major Injury

Thoraco-abdominal	12
Thoracic	5
Abdominal	15
Extremity	2
Neck	1

Deaths in Forward Hospitals (Head and Spine Injuries, cont'd).

Thirty percent (30%) of these cases died on the day of their admission, five from traumatic shock, two from hemorrhagic shock and one each from a pressure pneumothorax, a massive atelectasis, and respiratory failure.

In seven cases (22%) the deaths were based on this injury, four from meningitis and three from respiratory failure; and the spinal cord injury was a strong contributing factor in 10 other cases dying primarily of shock. The remaining 18 cases died from causes not particularly related to the spinal injury. The following table is of the causes of death in the 35 complicating spinal lesions.

TABLE XXII

Principal Causes of Death in 35 Cases with Complicating Spinal Injuries

Principal Cause of Death	Thoraco-Abdominal	Thoracic	Abdominal	Extremity	Neck	Location of Spinal Injury
Shock	2	2	6			L2,L1; C8&9, D5; D11,3, D12, L1&2, L12&3?
Unknown	3		2			
Meningitis	1		2	1		D11,L1&2,L4; D10
Anuria	3		1			L2,L2&3,D7;L1
Respiratory failure		1		1	1	C4, C5-7, C7
Atelectasis		1	1			D5&6; L4
Atelectasis with pneumonia		1				D10
Pulmonary embolus	1		1			D?
Peritonitis			1			L3
Pressure pneumothorax	1					D6
Massive emphysema	1					D?
Pneumonia			1			L1

Deaths in Forward Hospitals.

NECK INJURIES

In seven cases the neck was the only region involved and in 11 other neck cases there were minor associated wounds, making a total of 18 neck cases (1.5%) in this series. One case died of hemorrhage in the shock ward but the source of the hemorrhage was not stated. Forty-six per cent of these cases entered the hospital in severe shock but only one other case died of shock from hemorrhage, this latter case dying on the operating table while attempts were being made to control a lacerated common carotid artery and internal jugular vein. Tracheotomies were necessary in 44% of the cases.

It is interesting to note that eight cases, five with lacerated common carotid arteries, one with a lacerated internal carotid artery and two with thrombosis of the internal carotid artery, all developed a hemiplegia and died one to seven days postoperatively, with the exception of one case who lived for 19 days. The deaths in these cases were all ascribed to an encephlomalacia corresponding to the side injured, five of which were proved by autopsy. In all but one case the artery was ligated. In the one case, a common carotid laceration, a vein transplant was used with excellent results (temporal pulse on the injured side which was not present preoperatively) but the patient continued to have hemiplegia and died of an encephlomalacia on the 19th day. One other case died of a secondary hemorrhage and asphyxia on the sixth postoperative day but the autopsy did not reveal the source of the hemorrhage except that it arose in the deep tissues of the neck and filled the tracheo-bronchial tree through a large perforation of the trachea.

MAXILLO-FACIAL INJURIES

Seven cases (0.6%) were primarily maxillo-facial cases and in only two cases were there associated injuries, both of them minor. Besides having severe lacerations of the face and jaw, the following injuries were noted:

TABLE XXIII

Injuries in Maxillo-Facial Cases

Compound fracture of maxilla	4
Compound fracture of nose	3
Compound fracture of mandible	4
Compound fracture of hard palate	1
Basal skull fracture	1
Lacerated internal carotid artery	1
Lacerated tongue	3

Deaths in Forward Hospitals (Maxillo-Facial Injuries, cont d)

In two cases the trauma was severe enough to cause extensive cerebral damage without actual penetration of the skull. These cases died of a lacerated brain with a sub-dural hematoma and a severe contusion of the brain with sub-archnoid hemorrhage. Five of these cases died within the first 24 hours of their operation, the other two both lived 7 days. One of these latter cases died of meningitis due to an extension of the wound infection through the cribriform plate, and the other of an encephlomalacia, resulting from a thrombosis of the internal carotid artery due to a severe wound infection and ligation of the external carotid artery near its bifurcation from the common carotid.

BURN INJURIES

There were, in this series, eight cases (0.7%) that had extensive burns that involved large areas of the body (50-95%) and were not associated with other injuries. Four of these cases died within the first 24 hours of severe shock and, in three cases, a severe pulmonary edema due to burns of the tracheo-bronchial tree. One case died on the second day with a severe pulmonary edema, the cause of which was not stated. Two patients lived six days and died of acute glomerulonephritis and pulmonary embolus with a lung abscess respectively. In one case, the cause of death was not stated.

CARDIO-VASCULAR INJURIES

Major cardio-vascular injuries always exert a serious influence upon a case. Excluding those cases with trauma to the small vessels where collateral circulation is usually always good, there were in this series 176 cases (15%) having major cardio-vascular injuries.

Deaths in Forward Hospitals (Cardio-Vascular Injuries, cont'd).

TABLE XXIV

Cardio-Vascular Injuries Reported in 1165 Fatal Priority Cases

Vessel Injured (lacerated or perforated)	No. of Times Injured
Heart	12
Superior vena cava	1
Inferior vena cava	24
Pulmonary artery and vein	1
Right pulmonary vein	1
Aorta	7
Innominate Artery	1
Common Carotid artery	8
Common and external carotid artery	1
External carotid artery	2
Internal carotid artery	1
Jugular vein	8
Superior mesenteric artery and vein	1
Coelic axis	1
Portal vein	2
Portal vein and hepatic artery	1
Portal vein, hepatic artery, and inferior vena cava	1

	Artery and vein or Artery Alone	Vein Alone
Splenic	3	
Renal	4	1
Subclavian	1	
Axillary	5	4
Brachial	10	1
Common iliac	5	4
Internal iliac	6	1
External iliac	2	2
Common iliac and femoral	1	
Femoral	15	17
Popliteal	7	2
Stomach vessels	1	
Unknown source of hemorrhage		11

In addition to the above there was a notation of a vessel being in spasm or being occluded by a thrombus in seven other cases, all of which had a bearing on the outcome of the case.

Deaths in Forward Hospitals (Cardio-Vascular Injuries, cont'd).

Injuries to the cardio-vascular system accounted principally for 71 deaths (6.1% of all cases), or 40.3% of those cases with vascular injuries. Of these, ten were directly due to heart injuries. Following is the type of heart injury and the principal cause of death in each case:

TABLE XXV

Heart Injuries and Principal Causes of Death

Heart Lesion	Principal Cause of Death
Perforated right auricle	Shock from hemorrhage
Perforated left auricle	Cardiac tamponade
Perforated right A-V junction	Shock from hemorrhage
Perforated right ventricle	Cardiac tamponade
Perforated right ventricle	Cardiac failure (? tamponade)
Lacerated myocardium	Cardiac failure
Lacerated myocardium with thrombosis of coronary artery	Shock from hemorrhage
Lacerated left ventricle	Shock (cause not stated)
Contusion base of heart with many petechie	Ventricular fibrillation
Contusion left coronary artery and myocardium	Myocardial infarction

All of these cases died within the first 24 hours of their admission. Two other cases had heart lesions, perforation of the right auricle and a laceration of the myocardium respectively. In the former case the cause of death was not recorded and in the latter the patient died of an atelectasis postoperatively. The perforation of the right ventricle in the patient dying of cardiac tamponade was overlooked at the time of operation as only a simple debridement of the wound was done.

In 61 cases, death was due directly to hemorrhage from a major vessel or severe vascular injury and in 15 more cases the vascular trauma directly contributed to the fatal outcome of the cases. Of these latter cases, injuries to the carotid arteries resulted in cerebral degeneration and death in nine cases. Spasm and/or thrombosis of the major vessels to an extremity in five cases caused a vascular gangrene to part of the extremity, necessitating a second operation in four cases, and contributed to the establishment of a gas gangrene in the fifth case. In one case, trauma in the region of the superior mesenteric vessels resulted in a thrombosis which led to a vascular

Deaths in Forward Hospitals (Cardio-Vascular Injuries, cont'd).

gangrene of the bowel supplied by these vessels. Fourteen other cases died of hemorrhage but the source was not definitely stated.

In this series 58 cases died principally of an anaerobic infection (clinical anaerobic myositis). Four of these cases (7%) had major vascular injuries alone and seven (12%) had vascular injuries associated with compound fractures which were probably very strong contributing factors to the fatal outcome of the case. In nine cases, pulmonary embolism was found to be directly related to the vascular injury, the embolus arising from the vein injured, but in many cases the source of the embolus was not stated.

ANAEROBIC INFECTION

Fifty-eight cases (5%) in this series were reported as dying principally of gas gangrene. This diagnosis however was supported in only 10% of the cases by smear or culture, the diagnosis being made in most cases by the appearance of the patient and of the wound and on the course of the case. Of these cases, 28 were associated with compound fractures, four with major vascular injuries, seven with compound fractures and vascular injuries both, and 19 cases had soft tissue wounds only. The time interval between wounding and operation was prolonged in these cases, 57% entering the hospital 12 hours or longer after their injury, the shortest time interval being four hours and the longest six days. Seventeen cases (30%) were noted to have had the infection on entry or at the primary operation, the earliest seven hours after injury and the latest six days after injury.

TABLE XXVI

Gas Gangrene - 58 Cases - Average Time Interval - Injury to Operation

	Not Present on Entry	Present on Entry
With compound fracture	14 hours	26 hours*
With fracture and vascular injury	13 hours	none
With soft tissue injury only	10 hours	17 hours**
With vascular injury	6 hours	11 hours

*Not including two cases with interval of three and four days each.
**Not including one case with interval of six days.

Deaths in Forward Hospitals.

RENAL FAILURE

In this series there were 83 cases listed as having had renal failure; in 54 cases it was given as the principal cause of death and in 14 as the contributing cause. The diagnosis was made primarily on a clinical basis in most cases, nearly all of which had oliguria or complete anuria for a period of several days. Of these cases, six were associated with severe febrile transfusion reactions, in two of which there was a precipitation of hemoglobin in the kidney tubules microscopically. Three cases had hemorrhagic kidneys, apparently from trauma, two had a thrombosis of one renal vein, two had nephrotic kidneys, one had infarcts of both kidneys (cause not stated) and one had renal degeneration which was not explained in the record. In the remaining 68 cases, 16 at autopsy had enlarged, pale edematous kidneys and 12 had microscopic diagnosis of hemoglobinuric nephropathy.

These cases were all seriously wounded and as a group received 6.3 units of whole blood per patient before and during operation, the lowest being one unit (500 c.c.) of blood and the highest 15 units (7500 c.c.) of blood. The average time interval (injury to operation) for these cases was 11.2 hours and 73% were noted to be in severe shock. The majority of cases died on the fourth to the seventh day (average 4.7 days). Three cases were listed as having anuria on the first postoperative day but died from other causes, and one case lived for 15 days. In one of these former cases the N.P.N. was 99. The following table shows how these cases were related to the different types of injury:

TABLE XXVII

Incidence and Distribution of Renal Failure in 1165 Fatal Priority Cases

Type of Case	Frequency of Renal Failure	As Cause of Death	Distribution of Renal Failure
Thoraco-abdominal	13%	13%	31.3%
Thoracic	3.5%	2.4%	3.7%
Abdominal	8.5%	5%	49.4%
Extremity	7.3%	8%	15.6%

The above figures excluded all cases dying in the shock ward, during induction of the anesthesia, or during the operation.

Twenty-nine (34%) of these cases had direct injury to the kidney. In 14 cases the liver and kidney both were injured and in four the spleen and kidney were injured. Following is a list of organ injuries

Deaths in Forward Hospitals (Renal Failure, cont'd).

in these renal failure cases in 66 abdominal and thoraco-abdominal cases.

TABLE XXVIII

Organs Injured in Cases of Renal Failure

Stomach	15	Spleen	12
Small bowel	32	Pancreas	1
Large bowel	30	Vena cava	1
Kidney	29	Common iliac vein	2
Liver	28	Common iliac artery	1
Gall bladder	3	Urinary bladder	5

OVERLOOKED INJURIES AND POSSIBLE ERRORS IN JUDGMENT

In this series of cases there were in all, 47 injuries to the various organs which were overlooked at operation in 43 cases, or their presence was not suspected but was found in all cases at autopsy. This probably does not include all overlooked injuries as only 60% of these cases were autopsied. Cases dying before the operation could be completed were not counted.

Deaths in Forward Hospitals (Overlooked Injuries and Possible Errors in Judgment, cont'd).

TABLE XXIX

Injuries Not Suspected or Missed at Operation

Organ Injured	Type of Cases				
	Abdominal	Thoraco-Abdominal	Thoracic	Extremity	Neck
Heart	1		3		
Superior Vena Cava	1				
Trachea					1
Bronchus		1			
Esophagus			1		1
Stomach	1	2		1	
Small bowel (including duodenum)	4	4		3	
Large bowel	6	3			
Kidney		2			
Bladder	3			1	
Ureter	2				
Renal artery and kidney		1			
Renal vein	1				
Abdomen		1			
Liver		2			
Pancreas	1				
TOTAL	20	16	4	5	2

The case listed above as an overlooked abdomen was done as a thoracic case, the perforation in the diaphragm not being found at operation. This patient lived six days during which time he developed a violent peritonitis and distention. The abdominal organs injured were not stated.

In addition to the above there were 19 other cases that displayed technical accidents or possible errors in judgment, most of which might have played a part in the fatal outcome.

Deaths in Forward Hospitals (Overlooked Injuries and Possible Errors in Judgment, cont'd).

TABLE XXX

Technical Errors

Breakdown of suture lines	7	
Small bowel perforations	3	(1.4% of total)
Large bowel perforations	1	(2.3% of total)
Small bowel anastomosis	3	(1.9% of total)
Retraction of colostomies	5	(1.3% of total)
No colostomies in perforated colons	3	
Ileostomies (? necessary)	2	
Colostomy distal to perforated colon in case of situs inversus	1	
Descending colon exteriorized and transverse colon sutured	1	

These figures include only those cases where the complications developed in the forward hospital and not those which may have developed after evacuation. In the two cases with ileostomies, one was done because of a 1.5 cm. laceration of the cecum and the other because of persistent vomiting not controllable with a Levin tube. Both cases suffered from severe dehydration and severe skin reaction postoperatively which in the latter case, lead to a severe abdominal wall infection and dehiscence of the wound.

The following table shows the procedures done in 760 abdominal and thoraco-abdominal cases. In many cases the procedure was not stated.

Deaths in Forward Hospitals (Overlooked Injuries and Possible Errors in Judgment, cont'd).

TABLE XXXI

Procedures Done in 760 Fatal Priority Cases

Stomach		160 Injuries
Sutured	150	
Gastro-jejunostomy with resection	5	
Gastro-jejunostomy without resection	1	
Small Bowel		400
Sutured	214	
End-to-end anastomosis	154	
Side-to-side anastomosis	32	
Large Bowel		520
Colostomies	386	
Sutured	44	
End-to-end anastomosis	1	
Side-to-side anastomosis	1	
Resections	77	
Ileo-transverse colostomies spur	19	
Ileo-transverse colostomies with proximal colostomy	9	
Spleen		96
Sutured	1	
Splenectomies	83	
Liver		250
Sutured	15	
Packed	88	
Drained	81	
No treatment	15	
Gall Bladder		22
Cholecystectomy	16	
Cholecystostomy	6	
Kidney		146
Drained	60	
Nephrectomies	60	
Pancreas		30
Sutured	3	
Drained	17	

Deaths in Forward Hospitals (cont'd).

MEDICAL DISEASES AND ANATOMICAL ABNORMALITIES

There were, in 707 autopsied cases, 23 (3.4%) in which there were found co-existing medical diseases or anatomical abnormalities.

TABLE XXXII

Medical Diseases and Anatomical Abnormalities
Found in 707 Autopsied Cases

Rheumatic heart disease (old).... 3	Cirrhosis of the liver.......1
Jaundice (without liver injury).. 6	Gastric ulcer................1
Regional ileitis (gross)......... 1	Acute glomerulonephritis.....1
Cerebral malaria................ 2	Brain tumor (? type).........1
Malaria......................... 2	Horseshoe kidney.............1
Tuberculosis with cavitation..... 1	Old infarction, left ventricle (Age 35)...........1
Sarcoidosis of the lung (micro.). 1	
Situs inversus, complete......... 1	

The above table shows the type of lesions found in these cases. Most of these lesions exerted a direct influence on the fatal outcome of each case.

PRINCIPAL AND CONTRIBUTING CAUSES OF DEATH

The tables following are composite tables on all of these cases. In the majority of cases the principal cause of death is acceptable, in some cases however the true principal cause of death was not noted, a rather vague term being used (e.g. cardiac damage) without explanation. These cases were listed as recorded. Other cases were listed under headings which were not strictly principal causes of death, but which seemed to explain the fatal outcome of the case better (e.g. Cases dying from hemorrhage were listed that way rather than under shock. Bile peritonitis was listed as a cause of death because all these patients followed the same general course, gradually going down hill and dying in shock or cardiac failure). All cases listed under hemorrhage had severe active bleeding. All cases under bile peritonitis had large amount of bile in their abdominal cavities which was being constantly added to and not being drained out along the drains and packs. Cases dying before surgery was actually started are not included in these tables but are included under the different types of injuries already discussed.

Deaths in Forward Hospitals (Principal and Contributing Causes of Death, cont'd).

TABLE XXXIII

Number of Major Visceral Injuries in 1165 Fatal Battle Casualties

	Type of Case					
	Thoraco-Abdominal	Thoracic	Abdominal	Head & Neck	Extremity	Total
Heart	8	7				15
Lungs	74	86				160
Trachea		3		6		9
Esophagus		1		6		7
Aorta	3	1	3			7
Pulmonary vein	1	2				3
Stomach	78		81		1	160
Small bowel	45		352		3	400
Large bowel	76		444			520
Liver	116		134			250
Gall bladder	4		18			22
Common bile duct	1		1			2
Spleen	63		33			96
Kidney	57		89			146
Ureter			17			17
Bladder			49		1	50
Pancreas	12		18			30
Vena cava	6		18			24
Common iliac artery	3		3			6
Portal vein	2		3			5
Hepatic artery	1		2			3
Splenic artery			2			2
Mesenteric artery			1			1
Coeliac axis	1					1
Renal artery			2			2
Transected cord	11	9	16	3	4	43
Lacerated brain	1		8	52	4	65
Inter. Mam. artery		6				6
C.carotid artery		1		6		7
Int. carotid artery				1		1
Ext. carotid artery				2		2
Int. jugular vein				8		8
Subclavian artery				1		1
Innominate artery				1		1

Deaths in Forward Hospitals (Principal and Contributing Causes of Death, cont'd).

TABLE XXXIV

Principal and Contributing Causes for Death in 522 Abdominal Cases

Pulmonary	Primary	Contributing
Pneumonia	19	11
Pulmonary embolism	15	2
Pulmonary edema	0	25
Blast injury	11	6
Atelectasis	3	5
Pressure pneumothorax	0	4
Massive empyema	0	1
Cardiac		
Myocardial damage	1	0
Myocardial failure	18	5
Coronary thrombosis	1	0
Cardiac tamponade	1	0
Acute dilatation	0	1
Myocarditis	1	0
Coronary emboli	1	0
Rheumatic heart disease	0	1
Infections		
Anaerobic infection	19	8
Generalized infection	13	14
Meningitis	1	0
Hepatitis	0	5
Tetanus	1	0
Liver abscess	1	0
Cerebral malaria	1	0
Reactions		
Transfusion	4	0
Alsever's solution	2	0
Gas gangrene sera	0	2

Deaths in Forward Hospitals (Principal and Contributing Causes of Death, cont'd).

TABLE XXXIV (cont'd)

Abdominal	Primary	Contributing
Peritonitis	68	67
Bile peritonitis	9	3
Intestinal obstruction	9	0
Liver failure	3	0
Mesenteric thrombosis	2	1
Gangrene of small bowel (?cause)	1	0
Gangrene of large bowel (?cause)	0	1
Adrenal insufficiency	1	0
Cirrhosis of liver	0	1
Overlooked visceral injury	0	14
Breakdown of suture	0	7
Retraction of colostomies	0	2
Perforating bowel by wire suture	0	1
Head		
Lacerated brain	7	2
Cerebral edema	0	1
Contusion of brain	1	1
Encephalomalacia	0	1
Other		
Shock	187	63
Injuries	25	156
Unknown	45	95
Hemorrhage	31	6
Anuria	15	9
Anesthetic complications	3	0
Fat embolism	1	0
Diarrhea (? type)	1	0
Delirium tremens	0	1

Deaths in Forward Hospitals.

SUMMARY

A statistical report of 1165 fatal cases in forward hospitals in the combat zone of the North African, Mediterranean, and European Theaters is presented. The cases reported include only those that were classed as priority or non-transportable cases and who were treated by the 2nd Auxiliary Surgical Group throughout this war. The cases were further limited to those ending fatally in the forward hospitals while still under the care of the Group.

The first part of the report deals with preoperative treatment, shock, time intervals, anesthesia, wounding agents and autopsy rate in a general way for all the cases in this series. The cases are then broken down into nine different groups according to the type of their major injury and each group is presented separately and some of the problems, complications and causes of death are discussed. Statistics on cardio-vascular injuries, anaerobic infections and renal failures are then presented. Finally, overlooked injuries, possible errors in judgement, associated medical diseases and anatomical abnormalities found in the autopsied cases are tabulated. Charts are included showing the incidence of the majority of visceral injuries and of the primary and secondary causes of death in all of these cases.

TABLE XXXVI

Principal and Contributing Causes of Death in 182 Extremity Cases

Type of Extremity Injury		Shock	Anaerobic infection	Pulmonary embolism	Anuria	Blast	Unknown	Generalized infection	Hemorrhage	Injuries	Anesthesia	Lacerated brain	Air embolism	Pneumonia	Peritonitis	Adynamic ileus	Atelectasis	Fat embolism	Transfusion reaction	Anapaylaxis gas serum	Pulmonary edema	Hepatitis	Cardio-resp. failure
	Lower	19	16	9	5	3	2	1	2		1		1			1		1		1			2
	Ext.	3	1		1	1	2	4		47											5		
Alone	Mixed	10	7	3	1		1	1	1	1	1				1				1				2
			2					1		24											3		
	Upper	2	1		1		1		1					1									
	Ext.	1								6													
	Lower	11	4	4	1	1	2	3	2		2	2		1		1	1						
With	Ext.	2						2		28		1			1						1		
assoc.	Mixed	16	3	1	3	3	2			2			1		1								
						1	3			25					1						1	1	
injuries	Upper	4	2	1	2	3	1	1															
	Ext.		1				2	1		6		1		1			1				1		
Total Principal		62	33	18	13	10	9	6	6	3	4	2	2	2	2	2	1	1	1	1	0	0	4
Total Contributing		6	4	0	1	2	7	8	0	136	0	2	0	1	2	0	1	0	0	0	11	1	0

Figures in the squares are number of cases. Upper figure = Primary cause of death. Lower figure = Contributing cause of death.

TABLE XXXV

Principal and Contributing Causes for Death in 233 Thoraco-Abdominal Cases

Type of Thoraco-Abdominal Injury		Shock	Unknown	Anuria	Peritonitis	Hemorrhage	Injuries	Pneumonia	Atelectasis	Pulmonary embolism	Anesthetic complications	Extensive cerebral damage	Anaerobic infection	Blast injury	Ventricular fibrillation	Generalized infection	Empyema	Pressure pneumothorax	Fat embolism	Lung hematoma	Transfusion react.	Pulmonary edema	Bile peritonitis	Morphine intoxication	Retroperitoneal infection	Myocardial failure	Intestinal obstruction	Malaria	Meningitis	Cardiac damage
Alone	Rt.	25	4	8	1	2	4	2	3	1	.4			1	2			2								2				
			0		1	2	36		1	1					1	5				1		7	2	1				1	1	1
	Lt.	30	6	5	6	7	3	2	1.	1	1		3		1	2	1												1	
		5	4	1	9	1	42	1						1								2	1		1		1			1
	Bilat.	2				1	1		1	1																				
							4															2								
With extremity	Rt.	11	7	5	2	2	3	2	1	1			1	1		1				1			1							
		5	5	1	2	1	19			1												3			1					1
	Lt.	13	4	6	6	3	3	2	2	3				1			1		1		1									
		3	5		3		26	1	2									1				4		1						
With extremity and abdominal	Rt.																													
					1																									
	Lt.	1			1	1																								
		1						1						1																
With abdominal	Rt.	1							1																					
						1	1																							
	Lt.	1	2		1																									
				1			1															2								
With head	Rt.											1																		
							1																							
	Lt.																													
Total Principal		84	23	24	17	16	14	9	9	7	5	1	4	3	3	3	2	2	1	1	1	0	1	0	0	2	0	0	0	1
Total Contributing		14	14	3	16	5	130	3	3	2	0	0	0	2	1	5	0	1	0	1	0	20	3	2	2	0	1	1	1	3

Primary and contributing figures are in each square. Upper figure = Primary. Lower figure = Contributing.

TABLE XXXVII

Principal and Contributing Causes of Death in Head, Maxillo-Facial, Neck, Burn and Spine Cases

Type of Injury	Extensive lacerated brain	Meningitis	Unknown	Anaerobic infection	Contusion of brain	Internal hydrocephalus	Pulmonary embolism	Wound infection of head	Injuries	Encephalomalacia.	Hemorrhage	Thrombosis internal carotid artery	Anuria	Blast injury to lung	Shock	Contusion of spinal cord (C4)	Respiratory failure	Mediastinitis	Burn injury	Cardiac failure	Facial infection	Subdural hematoma	Sub-arachnoid hematoma	Pulmonary edema	Acute glomerulo-nephritis	Lung abscess
Head alone –	39	4	1		1																					
45 cases	1		36						8																	
Head with extremity	8	4	1	1		1	1	1																		
injury – 17	2		1						14																	
Maxillo-facial –		1	1		1				1	1										1		1				
7 cases	1		2						2												1		1			
Neck –			3				1			8	3						1	1								
17 cases			2						10			2	1			1		1								
Burns –			2												4										1	
8 cases			1																2					4		1
Spine –			3	1										1	1		2									
8 cases									8																	
Total Principal	47	9	11	2	2	1	3	1	1	9	3	0	0	1	5	0	3	1	0	1	0	1	0	0	1	0
Total Contributing	4	0	42	0	0	0	0	0	42	0	0	2	1	0	0	1	0	1	2	0	1	0	1	4	0	1

Figures in squares are number of cases. Upper figure = Primary cause of death. Lower figure = Contributing cause of death.

TABLE XXXVIII
Principal and Contributing Causes of Death in 96 Thoracic Cases

Type of Thoracic Injury		Shock	Unknown	Hemorrhage	Pneumonia	Pulmonarz embolism	Blast injurz	Atelectasis	Cerebral from shock	Ventricular eibrillation	Anesthesia	Anuria	Pressure Pt neuothorax	Generaliged infection	Cardiac failure	Injuries	Air embolism	Respiratory failure	Thrombosis pulmonary art.	Cardiac tamponade	Brain abscess	Empyema	Pulmonary edema	Peritonitis	Mediastinitis	Jaundice	Cebebral malaria
Alone	Rt.	7	2	4	3	4	1	1	2	2		1		1		1	1			1	1						
		4	2	1			1	3						1		16						1	2			1	
	Lt.	4	10	1	1		2	2	1					1													
		1	3					2	1							12							3				
	Bilat.	2			1	1																					
								1															2				1
With Extrimity	Rt.	3	1	2	2		1	1		1		1			1			1	1								
		2		1												8							3		1		
	Lt.	3	1	2					1	1	3		2											1			
		2	1				1									9							1				
	Bilat.	1																				1					
																2											
With extrimity and abdominal	Rt.	1				1		1																			
					1																				2		
	Lt.		1																								
																1											
With head	Rt.						1																				
																1											
	Lt.		1												1												
			2																								
Total Principal		21	16	9	7	6	5	5	4	3	3	2	2	2	2	1	1	1	1	1	1	1	0	1	1	0	0
Total Contributing		9	8	2	1	0	2	6	1	0	0	0	0	1	0	49	0	0	0	0	0	1	11	0	3	1	1

Figures in the squares are the number of cases. Upper figure = Primary causes of death. Lower figure = Contributing cause of death.

II ADMINISTRATION

II ADMINISTRATION

1. General.

The administration of this organization has been closely allied with its professional services. In fact, no distinct demarcation was permitted and all administrative matters were directed toward making available to theprofessional services the adjuncts required for the successful operational activities of the surgical and allied teams.

2. Organization.

a. Origin of the Unit.

The 2nd Auxiliary Surgical Group was constituted as an inactive unit of the Regular Army, 1 October 1933 pursuant to Letter, by AG 302.2 (8/16/33) dated 13 August 1933. It was activated at Lawson General Hospital, Atlanta, Georgia, 10 April 1942 in compliance with General Order No. 33, Headquarters Third Army, San Antonio, Texas, dated 1 April 1942. It was the first Auxiliary Surgical Group ever activated and organized in the Army of the United States. The original cadre of six enlisted men was transferred from the Detachment Medical Department, Lawson General Hospital, Atlanta, Georgia. On 1 May 1942, Colonel James H. Forsee, MC, (then Major) was assigned as the unit's commander by the War Department. He proceeded from Walter Reed General Hospital, Washington, D.C. and joined the unit on 9 May 1942.

b. Table of organization and Tables of Equipment.

The unit began functioning under T/O 8-512, dated 1 November 1940 and changed to revised T/O 8-571, dated 13 July 1942. The Group has functioned continuously under the basic organizational setup of the latter T/O and the T/E 8-571 which has been found satisfactory. The flexibility of this organizational arrangement has proven to be of the greatest practical importance, and the functional operational changes which have been followed throughout the overseas experience of the Group, have been found feasible and practical under this T/O and T/E. No experience has been had in the operation of the Professional Service Unit prescribed by T/O and T/E 8-500, dated 18 January 1945.

c. Functional Organizational Changes.

The functional organizational changes found feasible in the experience of this Group are:

(1) Orthopedic Surgical Teams. These teams have been organized on the same basis as other surgical teams and composed of the following personnel: One orthopedic surgeon, one assistant surgeon, one anesthetist, one surgical operating room nurse, and two surgical technicians.

II Administration (Organization, cont'd).

(2) Gas Teams: Fortunately, there has been no need for such teams and the personnel have been utilized on other teams.

(3) Miscellaneous Teams: These teams have functioned as shock teams.

(4) Two medical administrative officers have been members of this organization since September 1942, and their services have been of great value in the administrative organization. An additional MAC officer could be utilized to good advantage. Also one master sergeant as chief clerk is needed in the Group Headquarters.

d. Departmental Organization.

Other departments have been organized as diagramatically represented below. The simplicity of this organization is obvious and enables the most efficient operation of the Group.

GROUP HEADQUARTERS

DETACHMENT HQ	PERSONNEL SECTION	PROFESSIONAL SERVICES	NURSING SECTION	MESS	POSTAL SECTION	TRANSPORTATION	SUPPLY

GENERAL SURGICAL TEAMS	ORTHOPEDIC SURGICAL TEAMS	THORACIC SURGICAL TEAMS	NEURO SURGICAL TEAMS	MAXILLO FACIAL SURGICAL TEAMS	SHOCK TEAMS	DENTAL PROSTHETIC TEAMS

3. Function of the Group.

a. Primary.

The primary function of this Auxiliary Surgical Group has been to augment hospitals or other medical installations located principally in the forward area with surgical and allied specialty teams for the surgical care of severely wounded battle casualties. Three phases of this function may be described:

II Administration (Function of the Group, cont'd).

First: In all amphibious operations conducted by the North African or Mediterranean Theater of Operations and even before the Theater was established, surgical teams of this Group have participated in the initial or "D" day landings. Five such amphibious operations have been accomplished. The most feasible method of achieving the operational requirements of surgical teams of this Auxiliary Surgical Group in these landings has been to have them accompany first priority surgical hospitals (platoons of Field Hospitals) in the initial landings. (See also Section IV, Operation Activities).

Second: The responsibility for the surgical management of priority surgical casualties (non-transportable wounded) treated in the first priority surgical hospitals. It has been in this type of installation that the surgical and shock teams have carried out most of their work.

Third: The augmenting of the surgical staffs of Evacuation Hospitals with surgical teams of all types, in particular, orthopedic and neurosurgical teams. In our experience, every Evacuation Hospital actively engaged in the Fifth and Seventh Armies required additional surgical teams to supplement its own staff during periods of heavy fighting.

b. Secondary.

The supplementing of base hospitals with certain highly qualified surgical specialists to conduct or participate in the reparative phase of the surgical management of specialized surgical problems, especially thoracic and maxillo-facial plastic surgery.

In addition and during quiet periods at the front, many of the surgeons of the Group had the opportunity to study problems of surgical management as encountered in the base hospitals. This function permitted an excellent opportunity for the surgeon working in the forward area to become familiar with the later care of battle casualties.

4. Employment of the Group.

a. General.

This unit has been assigned to the Theater in which it functioned and its employment has been controlled by the Theater Surgeon. This employment has been principally with an Army and to a much lesser degree in the base sections. The assignment as a Theater unit has permitted the ready availability of certain personnel, especially qualified in the surgical specialties to function for extended periods in base installations.

II Administration (Employment of the Group, cont'd).

b. Employment in Base Sections.

The experience gained during approximately six months of 1943 in which the Group was attached to various base sections demonstrated these facts:

First, base hospitals seldom need augmentation of their surgical staffs, except occasionally by especially qualified specialists in certain fields of surgery.

Second, the function of surgical teams of an Auxiliary Surgical Group cannot be adequately accomplished at the base hospital level.

c. Employment in an Army.

(1) Experiences in the employment of the Group at this level and attached to an Army have been as follows (See also Section IV Operation Activities):

II Corps, functioning as a separate Corps, 15 November 1942 to 13 May 1943 (Tunisian campaign).

Seventh Army, 10 July 1943 to 17 August 1943 (Sicilian camapign).

Seventh Army, 15 July 1944 to 14 June 1945 (Southern France, Rhineland and Central Europe oampaigns).

Fifth Army, 9 September 1943 to 20 August 1945 (During all the campaigns in Italy).

This experience has indicated that the most efficient use of an Auxiliary Surgical Group is obtained when it is attached to and functions with an Army. A type Army of seven or more infantry divisions aotively engaged requires the services of an Auxiliary Surgical Group as organized under T/O 8-571 dated 13 July 1942.

(2) Standard Operating Procedure.

The following standard Operating Procedure of this Auxiliary Surgical Group functioning with an Army has proven efficient.

Standard Operating Procedure For the Use and Control of the 2nd Auxiliary Surgical Group.

(a) General.

An Auxiliary Surgical Group is composed of general surgical, orthopedic, neurosurgical, thoracic, maxillo-facial, shock,

II Administration (Employment of the Group, cont'd).

and dental prosthetic teams. The activities of the Group are controlled by the Group Headquarters. The function of the Group is to supplement the surgical service of hospitals. Primarily, the teams will function in Army hospitals and installations, but may be used in hospitals within the base section.

(b) Personnel:

1. The surgical teams consist of six persons as follows: Surgeon (Officer in Charge of Team), assistant surgeon, anesthetist, operating room nurse, and two surgical technicians.

2. The shock team is normally composed of one officer, one nurse, and two technicians.

(c) Equipment:

The teams are equpped with all essential surgical instruments and a portable anesthesia and suction apparatus. Tentage for quarters is a part of their organic equipment. They are not self sustaining and are dependent upon the installation in which they are employed for messing and housekeeping facilities.

(d) Transportation:

Teams routinely have their own transportation. The number of vehicles is limited and when teams are employed in Evacuation Hospitals they will seldom have their own transportation. Transportation furnished is primarily for the movement and supply of teams and only in emergencies will it be used for other purposes.

(e) Installations in which employed:

1. Employment in Evacuation Hospitals: In these installations, the teams will function under the supervisions of the Chief of the Surgical Service.

2. Employment in Field Hospitals: In these installations, the surgeon designated by Group Headquarters will be charged with the responsibility to the hospital commander for the surgical service of that hospital.

(f) Administration:

The Group Headquarters is responsible for the administration of the Group. Personnel records will be maintained in that office.

II Administration (Employment of the Group, Contd)

(g) Coordination:

All matters pertaining to the professional service and the employment of these teams in Army installations will be coordinated through the Army Surgeon.

(h) Requests for Teams:

Requests for teams to be placed on temporary duty with a hospital or installation will be made by the hospital commander or unit dental surgeon through the office of the Army Surgeon. This office will advise Group Headquarters of the need for teams at various hospitals. Requests for teams should, if possible, be anticipated several hours in advance to facilitate their movement.

(i) Release of Teams:

All hospital commanders are enjoined to cooperate in the maximum utilization of Auxiliary Surgical Group teams. To this end, the personnel will be released from hospitals and returned to their Group Headquarters as soon as their mission has been accomplished in order that they may be readily available for assignment elsewhere.

5. Employment of the Different Types of Teams.

a. General Surgical:

This team has been the type which, as anticipated, has been in the greatest demand. Its need has been greatest in Field Hospitals, functioning as first priority surgical hospitals. At this level, the triage of patients is based upon the urgency of the wound. Segregation on the basis of surgical pecialization is not feasible. Thus, the team functioning at this installation must be professionally equipped to care for any wound that renders the patient unsuitable for further transportation to the rear without surgery. This demands surgeons whose qualifications enable them to care for serious trauma in any part of the body. The general surgeon is best equipped to meet these requirements. It has been the good fortune of this Group to have a sufficient number of qualified specialists to permit their employment in these priority surgical installations. Their contributions in the care of specialized surgical problems have been of inestimable value and will be discussed under the employment of the surgical specialty teams. The general surgeon treating the wounds due to modern warfare has become the surgical specialist of trauma. Experience has demonstrated that four to six general surgical teams are necessary for the proper functioning of a busily engaged first priority surgical hospital. The teams have been charged with entire responsibility for surgical care of patients in these hospitals.

II Administration (Employment of the Different Types of Teams, contd)

b. Orthopedic Surgical Teams:

This team finds its greatest usefulness in Army installation in the Evacuation Hospital. At this level in the chain of evacuation there is a permissible segregation of patients within the hospital into surgical specialty categories which enables the orthopedic surgeons to devote their time to the care of extremity injuries. No hospitals, designated as specialty centers, have been established within the Army zone. However, the qualified orthopedic surgeons of this Group have made outstanding contribution to the management of extremity injuries in the first priority surgical hospitals. Through their expertness in the use of plaster of Paris bandages, they have taught many of the general surgeons important features in the use and application of this valuable dressing. By their accurate knowledge of the detailed anatomy of the extremities, they have demonstrated essential refinements in operative techniques, which have encouraged a better understanding of the management of severe extremity injuries. Finally, by employment in first priority surgical hospitals, the orthopedic surgeons have been brought into the closest contact with the problems related to the early surgical management of severe trauma of the extremities which has, of recent years, become more and more a part of this surgical specialty. Experience gained from the employment of orthopedic surgical teams in priority surgical hospitals has demonstrated that during busy periods, the services of a qualified orthopedist are not capable of being used to the greatest advantage. This results from the fact that the highly trained orthopedic surgeon is seldom a qualified general surgeon and is unable to take his regular turn, or shift, on the operative schedule for the care of all admissions to the hospital. Thus, it has become more and more evident that the greatest utilization of the highly trained and qualified orthopedic surgeon, who is not also a qualified general surgeon, requires that he be placed in installations where reparative and reconstructive surgery are being accomplished. This is in fixed hospitals, either overseas or in the Zone of Interior. To this end, the qualified orthopedic surgeons have gradually been transferred from this Group to numbered General Hospital where their capabilities in the management of the more strictly orthopedic problems could be utilized to a greater degree. This should not be meant to imply that qualified orthopedic surgeons should not be included in the organization of an Auxiliary Surgical Group but rather that, in the case of this unit, the need for the highly trained orthopedic surgeon has become less as the general surgeons have become more experienced in the management of wounds of the extremities.

c. Thoracic Surgical Teams:

In general, qualified thoracic surgeons have had considerable training in general surgery and are capable of doing abdominal and extremity surgery as well as thoracic surgery. Thus, thoracic surgical teams of this Group have been extensively employed in Evacuation and Field Hospitals. Also, appreciable use has been made of the thoracic surgeons

in this Group in base hospitals designated as thoracic surgical centers. The employment of thoracic surgeons in priority surgical hospitals has been especially profitable in contributing to and emphasizing the following essential principles in the early management of severe wounds of the thorax:

The early removal by thoracentesis of blood and air, within 24 hours, in injuries causing a hemothorax.

The employment of intercostal nerve block to relieve thoracic pain and aid in the expectoration of secretions from the tracheobronchial structures.

The use of catheter suction for the removal of tracheobronchial secretions.

Frequent bronchoscopic aspiration of tracheobronchial blood and mucus, in the preoperative, operative and postoperative management of intrathoracic and intra-abdominal injuries.

The great importance of the endotracheal method of administering the anesthetic agent in intrathoracic and intra-abdominal injuries.

The focusing of attention in intrapleural injuries to the rapid and complete re-expansion of the lung and early restoration of the functional integrity of the respiratory system.

The function of the priority surgical hospital in determining the transportability of casualties suffering from thoracic injuries.

The dissemination of information regarding thoracic physiology and its application in the management of war wounds of the thorax.

Experience has indicated that a very appreciable percentage (approximately 50%) of the casualties suffering from intrapleural injuries alone are transportable, or may be made transportable, by the employment of measures enumerated above. Under this plan, the need for the thoracic surgical team increases in the Evacuation Hospital as more thoracic injuries will be treated in these installations. Two thoracic surgical teams working on 12 hour operating schedules have been able to efficiently care for a large volume of thoracic wounded and organize excellent surgical sections in the hospital during periods of great activity at the front.

The excellent opportunities afforded several of the thoracic surgeons of the Group to work in base hospitals has greatly enhanced the knowledge and experience of these surgeons and contributed appreciably to the high standards of surgical care which the patients suffering from thoracic wounds have received. The listing of their contributions in this

field of surgery requires a recapitulation of the advances in the reparative phase of the surgical management of war wounds of the thorax. The problems relative to the removal of intrathoracic metallic foreign bodies have occupied an important place in this work. "The radical management of massive organizing hemothorax by thoracotomy, evacuation of the clots and decortication of the lung has proven its effectiveness in returning soldiers to duty and appears to have diminished the incidence of empyema. The same procedure applied to established posttraumatic empyema with penicillin therapy as an adjunct, is followed by immediate healing with a fully expanded lung" (Churchill). The thoracic surgeons of this Group initiated this method of management in NATOUSA.

d. Neurosurgical Teams:

The employment of neurosurgical teams in the first priority surgical hospitals has been practiced sufficiently to conclusively confirm the view that casualties suffering from brain injuries transport well and preferably should receive their initial surgery in Evacuation Hospitals. Two neurosurgical teams working 12-hour operating shifts in a busily engaged Evacuation Hospital are ideal. In general, however, one neurosurgical team has, during such periods, been required to carry the entire load. In addition to the employment of these teams in Evacuation Hospitals, there have been occasional opportunities for their use in base hospitals. Here again the advantages gained from observing the late results of the surgical management carried out in forward installations have been of great value to the surgeons of this Group.

e. Maxillofacial Plastic Surgical Teams:

Experience in the employment of these teams has included their functioning in Field, Evacuation and General Hospitals. Their use in Field Hospitals as strictly specialty teams has proven untenable. The Evacuation Hospital is the feasible installation in which these teams should be employed and one team has been sufficient to meet the requirements of such a hospital. When the regular staff of the hospital has had a maxillofacial surgeon, it has not been necessary to augment that hospital. The greatest utilization of these teams has been in General Hospitals or hospitals designated as centers for the care of maxillofacial injuries. Experience has indicated that the need for this type of surgical team in this Auxiliary Surgical Group has been limited and never more than two teams have functioned as such at any one time. On the basis of this experience it is believed that qualified maxillofacial surgeons could be better utilized in other types of medical units and maxillofacial plastic teams deleted from the organization of an Auxiliary Surgical Group.

f. Shock Teams:

The employment of these teams has been almost exclusively in the first priority surgical hospitals and it is impossible to over-

estimate their value in the proper care of the nontransportable casualties. The need for officers interested and qualified to head shock teams has always exceeded the number available. It is desired to emphasize that the professional qualifications for the officer in charge of the shock team are exacting. Experience has indicated that, in general, the competent young internist becomes a better shock officer thana young surgeon. The services of a qualified shock officer are invaluable to the successful surgical management of the severely injured battle casualties and the opportunities afforded for his observations in the manifestations of clinical shock are indeed great.

The function of the officer in charge of a shock team has been clearly defined and practiced by this organization. His function is to carry out shock therapy measures under the direction of the surgeon who will undertake the operative surgery. The operating surgeon is charged with the entire responsibility for the proper surgical care of that paient and the patient is not served up to him as an individual whom the shock officer has decided is ready for surgery. This function has in no way interferred with the initiative of the shock officer but on the contrary has permitted the closest coordination with the surgeon and stimulated both to investigate and analyze the clinical data available relative to the recognition and management of shock.

g. Dental Prosthetic Teams:

The demand for dental prosthetic teams has constantly exceeded the number available. These teams composed of one dental officer and three enlisted men have been employed in almost all types of installations and under varied conditions. Prior to May 1944, they had functioned frequently in conjunction with the base section dental laboratories and in dental clinics set up in the Corps and Army areas. In each of these installations they functioned efficiently and rendered very valuable service to the troops. In May 1944, mobile dental laboratories (trucks) were placed in operation for these teams. All subsequent function of these teams has included the use of the mobile dental laboratory. The mobility of the laboratory has enabled a freedom of movement which has permitted teams to be employed especially in areas and with units in the Army which otherwise would be required to send their patients an appreciable distance, even requiring hospitalization, for dental prosthetic work. The method which has been found most efficient is for the unit dental surgeon to request through the Army Surgeon a dental prosthetic team to be on temporary duty with the designated unit. The team with its own transportation and tentage for quarters functions with that unit untill it completes the dental prosthetic work required. It is the responsibility of the unit dental surgeon to have the patients report at the specified time for treatment and that the proper dental preparation of the patient's mouth has been carried out prior to reporting for dental prosthetic work. On completion of its work the team is available for duty with another unit. This flexibility of employment has permitted the

greatest utilization of these teams affording their services to units located in areas where they often encountered considerable difficulty in obtaining needed dental prosthetic work. By the above method of employing these teams, the amount of time lost from duty, especially among combat troops, has been minimized.

The experience of this Auxiliary Surgical Group has been such as to encounter little demand for oral surgeons. Therefore, the dental officers of this Group have been engaged principally in dental prosthetic work and general dentistry.

7. Functions of Group Headquarters.

a. General:

The activities of this Auxiliary Surgical Group have been directed by the Group Headquarters. These activities have been coordinated to effect a uniformity of control which has established the identity of the Group and has integrated its functions not only in the commands under which it has served, but also in the installations in which personnel of the Group have been employed. The problems of the professional services have guided the administrative functions and this guidance has been found to enhance surgical care during military operations. These facts are evident from a study of the professional service section of this report. The accomplishments of any organization are a reflection of its leadership, and the function of the Group Headquarters has been to accept the responsibility of proper leadership in all phases of the activities of the Group. The physical location of the Group Headquarters has been an important consideration as it must be situated in close proximity to the area in which the teams of the Group are employed. This permits close liaison with the Army Surgeon, particularly with his surgical consultant and operations officer. Likewise, personal contact with the teams, the commanding officers and chiefs of the surgical services of the hospitals or medical installations in which the elements of the Group are employed is more easily maintained. The Group Headquarters establishes housing, either tents or buildings, messing and general housekeeping facilities for the Group. These requirements vary greatly depending upon the activity at the front and the demand for teams in forward installations. In extremely busy periods of heavy fighting the personnel on duty at Group Headquarters is very minimal, while during quiet periods at the front the major portion or entire command may be assembled at Group Headquarters. Thus, the requirements for the above facilities are constantly changing and planning must always allow for maximum demands. The departmental activities maintained at Group Headquarters are: professional service, personnel section, nursing section, transportation, supply, medical detachment, mess and postal section.

II Administration (Function of Group Headquarters, contd)

Early in the overseas experience of this organization it became evident that the Group Headquarters, or a detachment of Group Headquarters should be readily available to any sizeable detachment of teams regardless of the area in which they were employed. The feasibility of this plan was exceedingly well demonstrated during the campaigns of Southern France, the Rhineland, and Central Europe when a large detachment of teams from this Group was employed in these areas. A detachment of Group Headquarters functioned with these teams during these campaigns.

The professional service section of Group Headquarters has been a most important department of this organization. Early in the training period of this unit an extensive study was made from the available literature dealing with the management of war wounds. The analysis of this literature clearly demonstrated the paucity of factual data referable to this subject. This lead to an appreciation of the need for carefully recording all data which the surgical experience of members of this Group might encounter. To simplify the recording of these data, a standardized individual case record form was prepared prior to embarking for overseas (see page 841). This form permitted an adequate record which if carefully completed would make available the essential technical data regarding each patient treated by members of this Group during the period in which the patient remained under their care. In addition, a form for a brief follow-up note was standardized. This form was attached to the patients' medical records and a fair percentage of follow-up studies were forwarded to this organization from hospitals in which the patient received further treatment. Each surgeon in charge of a team was responsible for completing the individual case record. These case records were retained at the Group Headquarters. In addition, all surgeons were encouraged to keep careful case records for their own personal files on all patients treated. The Group Headquarters became the repository for the records of the professional activities of the members of the Group. From these data many important studies have been made which had an immediate bearing on the surgical management of the wounded. Constant diligence was maintained in encouraging the surgeons, anesthetists and officers in charge of shock teams to analyze these data and submit reports of their findings. Each officer in charge of a team was required to submit periodic reports of this team's activities and these reports were made available to all members of the Group and to the Theater Surgeon. From this beginning there has been gradually built up a series of approximately 22,000 individual case records dealing principally with first priority surgical injuries. This series of case records is believed to be unparalleled in the annals of American surgery. It is upon the factual data contained in these records, combined with the personal experience of the members of this Group that the professional service section of this report is based.

II Administration (Functions of Group Headquarters, contd)

b. Personnel Administrative Section:

The personnel section of Group Headquarters has been charged with the management of personnel administrative matters. The problems of placement or assignment of personnel have not been delegated to this department. Early in the overseas experience of this Group, the feasibility of handling all personnel administrative matters, records, etc., at Group Headquarters was clearly demonstrated. During the early campaigns in which elements of this Group participated personnel records accompanied members of the teams. It was found that due to the frequent moves of the teams and the temporary nature of their attachment to other organizations that the personnel records were often not kept current or accurate and not infrequently the records were lost. Enlisted men were occasionally not paid for several months. The correction of the deficiencies in the records entailed considerable time and difficulty as well as unnecessary delay as corrective measures must await the teams' return to Group Headquarters. Following this experience, the service records, preparation of payrolls and the pay of all personnel, handling of allotments, individual qualification cards, 66-1, 201 files and all other personnel administrative matters have been functions of the personnel section of Group Headquarters.

The administrative matters relative to the issuance of orders for team movements, changes in team assignments, the typing and mimeographing of many scientific papers on professional subjects have been carried out by members of this section. The personnel available for assignment to this very busy department has been insufficient and this has resulted in unusually long hours of work for its assigned members. There is a definite need for a master sergeant at Group Headquarters to have supervision of this section.

The work of this section becomes readily evident when it is noted that the officer strength of this organization (196) is equivalent to that of two infantry regiments. The following data are pertinent. A total of $129,919.00, requiring 1272 separate vouchers was transmitted to the United States through the personnel office since the Personal Transfer Account system was inaugurated (May 1943). During the months of October, November and December 1944, 640 officers' pay vouchers were prepared amounting to payments of $209,009.33, and enlisted payrolls of cash payments in the ammount of $22,893.16 were prepared and paid., To obtain the signatures on payrolls and officers' vouchers and to accomplish payments often required a 500-mile trip over a period of two to four days to contact all members of the Group.

c. Nursing Section:

The requirements for nurses assigned to this Group have been exacting. The need for maintaining the specialized nursing service

of the organization at the highest possible level of competency is a prerequisite to its successful operation. The nurse personnel have been carefully selected on the basis of their professional qualifications. The nurse must have detailed knowledge of her duties whether as a surgical operating room nurse, on a shock team, or as an anesthetist. In addition, she must possess the temperament and adaptability required for the cheerful, efficient performance of long and difficult surgical procedures performed in forward hospitals which are often subjected to enemy attack. Excellent health is essential, as living conditions are seldom ideal and duty is often very strenuous. Throughout the experience of the organization the nursing personnel have met these requirements in a highly commendable manner.

The principal chief nurse is stationed at Group Headquarters. The personnel records for the nurses are maintained in her office. She is responsible for the supervision of the nursing functions of the teams and maintains close personal contact with the teams in all installations in which they function. Nursing activities are coordinated with the chief nurse of these installations and with the Army Director of Nurses. The assistant chief nurse has functioned as a surgical nurse, assistant to the principal chief nurse, and as the chief nurse in the large detachment of teams which functioned in the campaigns of Southern France, the Rhineland, and Central Europe.

d. Transportation:

The major defect in the T/E 8-571 has been in the inadequate allowance of transportation. This deficiency has been overcome by an additional authorization, in excess of T/E by the Theater Commander. This authorization has been as follows and has been found to be barely adequate for meeting the minimum requirements for this Group. One truck, and a one ton trailer plus a weapons carrier for two surgical teams is ideal.

Truck, 3/4 ton, 4x4 W/C	ea.	10
Truck, 2 1/2 ton, 6x6, cargo	ea.	15
Trailer, 2 wheel, 1 ton	ea.	10
Trailer, water, 250 gallon	ea.	3
Truck, 1/4 ton 4x4	ea.	2

The essential piece of transportation is the two and one-half ton truck. This vehicle has the durability and capacity to travel over extremely poor roads carrying personnel and equipment which, in our experience, could not have been accomplished as well by any other vehicle. This truck plus a one-ton trailer is the minimum required to move two surgical teams. The three-quarter ton 4x4 weapons carrier is an excellent personnel carrier but in no sense has it been found to be a replacement for the two and one-half ton truck. The "peep" is an economical means of transportation most useful in maintaining contact with teams functioning in various hospitals. Water trailers have been needed to transport potable water. In no situation in which this Group has functioned was potable water available from local native sources.

II Administration (Transportation, contd)

The transportation section operates at Group Headquarters and is responsible for the dispatching of transportation, its maintenance, and coordinating the vehicular requirements of actively engaged teams. In order to minimize the transportation requirements a small pool of vehicles are held in reserve at Group Headquarters and a minimal number of vehicles are allotted to functioning teams. This permits independent movement by the teams. During periods of rapid advances and when many teams are moving it is necessary to make use of a shuttle system and all transportation facilities are severely taxed.

The following data, estimated only, are of value in envisioning the work of the transportation section:

(1) Total number of vehicles which the Group has operated -- 58.
(2) Number of miles vehicles have traveled -- 900,000. (This is equivalent in distance to thirty-six times around the world.)
(3) Gallons of gasoline consumed -- 95,000.
(4) Number of accidents in 29 months of operation -- 16.

From these data it is evident that a large number of drivers and several automotive mechanics are required. This problem has been met by employing enlisted personnel not actively engaged on teams in the maintenance and driving of these vehicles. Continual emphasis has been placed on the training of mechanics and on the careful driving of vehicles. During the period in which the organization was functioning in two different Theaters of Operations, the transportation available to the Group was often hard pressed in the movement of teams and at times had to be supplemented.

f. **Supply:**

General.

It has been the experience of this Auxiliary Surgical Group that supply problems have varied and have evolved from conditions peculiar to the type of command to which the Group was attached and the locations in which the teams were employed. During the first six months of overseas operation the Group Headquarters was attached to base sections. All supply procedure had to be carried on with base depots. Movement from one base section to another necessitated complete renewal of the authorizations for the equipment held in excess of T/E that was necessary for the efficient operation of the Group. For the past 22 months, this Group has been functioning with an Army. With this employment problems of supply have been considerably simplified and with minor revisions an adaptable unit supply system was maintained with relative ease.

II Administration (Supply, contd)

The supply procedures for the entire organization were coordinated through the Unit Supply Section located at Group Headquarters. Surgical teams functioning on temporary duty at other medical installations were dependent upon Group Headquarters for their supplies and equipment and were required to draw all equipage from the Unit Supply. In this manner an accurate check could be kept on all equipment and proper accountability maintained. Experience taught that by maintaining unit supply in standard boxing and crating it could be moved and set up quickly and efficiently. This procedure also simplified the estimation of cubages and weights on occasions when equipment has had to be moved by rail or ship.

Tentage.

This organization has been quartered in tents throughout the greater portion of its overseas experience. The T/E 8-571 does not authorize any tentage. The following allowances for tentage have been met by authroization by the Theater Commander and have been adequate:

Tent, pyramidal (complete with pins and poles) . . .	ea.	80
Tent, storage (complete with pins and poles)	ea.	8
Tent, wall large (complete with pins and poles) . .	ea.	6
Tarpaulin, 12 x 17	ea.	5

Medical Department Equipment.

The following additional items of Medical Department equipment have been authorized by the Theater Commander and have been found desirable to retain as essential to the Medical Department Equipment list MD item 9720300; Auxiliary Surgical Group:

CLASS 3 ITEMS

3054500	Bronchoscope, 8 mm x 40 cm, adult	ea.	24
3402300	Ophthalmoscope, eledtric	ea.	4
3441200	Retractor, flexible, abdominal	set	28
3535000	Spreader, rib	ea.	24
3493200	Shears, rib, Bethune, 13 1/2 inch	ea.	24
3548500	Tube, aspirating, 50 cm	ea.	24
3550800	Tube, aspirating open and warning stop at 40 cm	ea.	24
3558000	Tube, aspirating, trachea, size 5	ea.	24
3621500	Batterybox	ea.	24
3670300	Electrosurgical unit portable	ea.	4
3774700	Stop-cock, one way	ea.	28
3775008	Suction Aparatus, portable electric *	ea.	32

(* An improvised suction machine was devised by a member of the Group and used during the early campaigns in NATOUSA. Brewer, Lyman A. III, Portable Handdriven Suction Machine. Bull. Med. Dept. US Army No. 75119 (April 1944.)

II Administration (Supply, contd)

CLASS 7 ITEMS

7099400	Table, orthopedic, portable	ea.	6
7751000	Chest, tool, small	ea.	1
7789000	Cylinder, valve adapter, high pressure ...	ea.	42
7581505	Machine, Office, duplicating, handoperated	ea.	1

CLASS 9 ITEMS

9350000	Anesthesia, apparatus, portable	ea.	42
9753500	Chest, field plain	ea.	60
9950000	Sterilizer, dressing & utensil, horizontal	ea.	1

Comment is warranted at t is point to emphasize the need for a durable container approximately twice the size of the chest, field, plain (item 9753500) for the transporting and filing of personnel records, office supplies, etc., for all field medical units. Due to the diversity of requirements and ideas among even the same types of units, it seems desirable not to attempt an elaborate interior design for this chest, but rather that emphasis be placed on their durability. This would eliminate a significant problem in removing the need for the construction of many boxes which are often short lived. This was a major problem, especially in North Africa and Italy, as the lumber supply was extremely limited.

g. Detachment, Medical Department:

The functions of the detachment, Medical Department have been varied. The Detachment Commander has, in general, been charged with the additional duties of supply and transportation officer. These activities have been coordinated in his office. The high percentage of efficiently qualified technicians with the small number of basics among the enlisted men has required that many of the routine duties necessary in the maintenance of a military organization have been performed by these technicians when they were not actively engaged on functioning teams.

h. Mess:

The Ration.

During much of the first year overseas, the ration furnished consisted largely of "C" rations. During the first months in Morocco, it was possible to supplement the "C" diet with fresh eggs procured locally and later in Tunisia some fresh vegetables and melons were available. The prevalence of intestinal-borne diseases reduced the purchase of such supplements to a minimum. The Group was fortunate in having well trained cooks but the repeated issue of Vienna sausage, spam, chili-con-carne, dehydrated potatoes, beets, carrots and powdered eggs severely taxed their ingenuity in the preparation of appetizing foods.

II Administration (Mess, contd)

Rations in Italy improved and an almost daily issue of fresh meat, occasional issue of fresh eggs and butter, and fresh fruits and vegetables in season, provided excellent fare. In Southern France "B" rations were available early in the campaign, and the gratitude and friendliness of the French people produced many gifts in the form of fresh eggs, potatoes, vegetables, poultry and cheese. However, upon entering Germany, due to the added burden of feeding hundreds of thousands of displaced persons and released prisoners of war, the basic ration was cut 10%. In addition, no outside purchases were permitted. This cut was noticeable in the mess kit of the individual soldier.

Mess Sanitation.

The standard methods as prescribed in the basic field manuals have been used for the control of flies, washing of mess kits and utensils and safeguarding perishables and other food. Garbage was occasionally buried but for the most part was picked up by the local populace who were more than anxious to get it. Some difficulty was encountered in keeping the wash water for mess kits at a high enough temperature with the standard burner unit. For a while this was taken care of by the use of an improvised gasoline heater; gasoline was piped underneath the G.I. cans containing the wash water where it was ignited, and the ensuing heat vaporized the gasoline as it left the pipe making a very hot flame that kept the water at the boiling point. This method was dangerous and had to be carefully supervised. It was abandoned upon the issue of the new immersion type water heater which has proven ideal. During the two and one-half years of overseas duty no diarrheas or food poisonings were imputed to the unit mess.

Civilian Mess Attendants.

Following the cessation of hostilities, civilian personnel were employed as mess attendants and kitchen police. This released enlisted personnel to take part in the educational and recreational programs as prescribed by redeployment directives.

Military Personnel.

The unit mess has been staffed with the same enlisted personnel throughout; the turnover has been slight. They were selected by their qualifications and desire for that type of work and consequently have done a superior job. On occasions, medical officers and nurses who were not actively engaged with the professional duties on surgical teams have acted as Mess Officers. Their periods of employment were usually necessarily brief as they would have to leave the position when their teams were called out. This was disadvantageous to the efficiency of the mess. A Mess Officer, preferably of the Medical Administrative Corps,

who acts as Mess Officer in addition to his other duties, is required to afford the command the best opportunities, through its mess, for good health and a high morale.

i. Unit Postal Section:

In the case of troops overseas, mail is possibly their one link with life as they formerly knew it. Hence, the reasonably prompt receipt and dispatch of communication between troops and the home front becomes all importnat.

Because of the nature of this organization and the wide deployment of its personnel subject to frequent and oftentimes unexpected changes, the prompt delivery of mail presented an unusual problem.

Early in the North African Campaign, it was noted that the time required for the delivery of mail from Group Headquarters through existing Army Postal Units was too great -- sometimes running into weeks. Throughout the Italian, Southern France and Germany Campaigns, this condition was corrected by expediting the dispatch of incoming mail from Group Headquarters to the medical installation in which the surgical teams were employed. Much of the mail received at the Unit Post Office for personnel on temporary duty elsewhere was delivered by individuals from Group Headquarters whose duties involved direct contact with the functioning teams. They might be replacement personnel for forward teams, messengers, and in many instances, the Commanding Officer or his representative. Mail was frequently collected also by members of teams in the field who returned temporarily to Group Headquarters on other business. This greatly expedited the delivery of mail and was a factor of great morale value to the members of surgical teams. Outgoing mail was well taken care of by the established Army postal facilities which maintained postal service for the installation to which our teams were temporarily attached.

Mail for personnel on detached service in far removed areas or those hospitalized was in most cases delivered through Army postal channels. The proportionately large number of officer personnel and the presence of many well trained enlisted technicians in the assigned strength of this organization seemed to influence the volume of mail, both incoming and outgoing which numbered many times the volume to be expected from a unit with a similar number of members. The absence of lost mail, the absolute minimum amount of delayed delivery mail and the high morale of the organization are all testimony to the efficiency of the unit mail system.

In addition, the characteristic functions of a post office were carried out. These included parcel post facilities, postage, expeditionary force senders' composition messages and money orders. The unit post office acted as a message center between Group Headquarters and detached personnel.

From time to time the unit post office has been confronted with the problem of providing postal service for many additional attached personnel such as surgical teams from other Auxiliary Surgical Groups during the campaign in Southern France and Germany. The system of handling mail was readily adaptable to existing and varied conditions and as a result, mail service continued to function smoothly throughout the entire period that this Group has been overseas. The return of attached personnel to their units brought the problems of promptly forwarding mail to the correct stations of the personnel involved. A complete set of locator cards kept by the unit post office proved to be of immense value in accurately carrying on this service.

8. Training:

a. General.

Constant diligence has been exercised throughout the history of this organization in the training of its personnel. A policy has been maintained of having, as nearly as possible, two individuals trained for the performance of each essential job.

b. Training of Assistant Surgeons.

It is of particular interest to note that during the overseas experience of this organization, 16 officers who originally served as assistant surgeons, or entered the Group as assistants, have in the past year made creditable records as heads of surgical teams. It is believed fundamental to the requirement of having well qualified surgeons in charge of surgical teams of an Auxiliary Surgical Group, that emphasis be placed on the selection of junior surgeons capable of being trained within 12 to 18 months to have charge of their own surgical teams. Fortunately for this organization, a very appreciable number of the assistant surgeons assigned were sufficiently well trained prior to their entering the military service to permit them to take over the duties of the operating surgeon as soon as a vacancy was available. It seems inevitable, under the disrupted plan of prewar medical education and postgraduate training, that the number of officers with professional qualifications similar to those originally assigned to this Group as heads of surgical teams would not be available for such assignment if World War II had continued.

c. Training of Anesthetists.

The training of medical officers in anesthesiology has been of particular importance to this organization. There has never been an adequate number of qualified physician anesthetists to staff all of the surgical teams of the Group. Fortunately, the demands for the engagement

II Administration (Training, contd)

of all of the teams progressed slowly and reasonable opportunity has been afforded to train other officers in anesthesiology. Also, we have been fortunate in having several especially well qualified nurse anesthetists who have rendered yeoman service as anesthetists of surgical teams. However, the demand for replacements of qualified anesthetists is ever present, and here again there is difficulty in securing competently trained physician or nurse anesthetists. To meet these demands training in this field has been continuous and several assistant surgeons have been rotated in their duties to receive training in anesthesiology whenever conditions permitted. This is a field of medicine which is destined to become increasingly important during the postwar period. It has been a universal comment of the operating surgeons of this Group that their work in the surgical care of the most seriously wounded could not have been accomplished had it not been for the excellence of the work of the anesthetists. Likewise, all of these surgeons will demand the best of anesthesia in their own practices.

d. Training of Army Nurse Corps Members.

The training of nurses in operative surgery has not presented any major problem to this organization. There has, however, been a steadily increasing need for replacements for the experienced surgical nurses. Throughout the history of this unit it has been the policy to alternate nurses in their assignments to surgical teams, and during relatively quiet periods, to assign the less experienced nurse to the functioning surgical teams. This permitted the training of several nurses, who have later been able to take over this work during the periods of great activity.

It has at times been suggested that enlisted men might be trained to replace surgical nurses in the forward area. The experience of this organization has been such as to definitely disfavor this suggestion. The period of training required in the nurses' education cannot be rapidly duplicated by short courses of training of enlisted men. However, if such a change should be required, particular attention should be focused on selecting men with high scores as determined by the Army General Classification Test. Graduate male nurses should, when possible, be selected. A minimum of six months didactic and practical training in surgical operating room methods should be required in the training of these men.

e. Training of Enlisted Men.

The basic and advanced training in military subjects which the enlisted men of this Group underwent in the United States has proven to be of real practical value. Likewise, the teaching and training which they received in the Enlisted Men's Technicians School can be said without

reservation to have been excellent. Doubtless, this preparation made it much easier for them to participate rapidly in the practical application of their duties as surgical and medical technicians. There is, however, one point worthy of emphasis, and that is that one learns very rapidly certain requirements of seeking cover, observing blackout rules, and avoiding traffic violations in forward areas when exposed to the immediate hazards of enemy action. Further, the repetition of completed training programs, schedules, etc., soon loses its significance after many months of actual field experience, and should be held to the very minimal requirement. This does not imply any deviation in the rules of military discipline and courtesy, for they must be constantly emphasized and practiced.

9. Personnel:

a. General.

The problems of personnel management are, in general, directly proportional to the percentage of the personnel performing duties in which they are interested, desire to perform and are qualified to perform. The officer personnel of the Group was carefully selected on the basis of their professional qualifications. This selection has been continued during its overseas experience and personnel placement problems have been minimal. Certain problems in personnel management do arise and have been handled as individual matters with all efforts being directed toward placing the individual in the position for which he is best qualified.

In the early part of August 1942, the Commanding Officer of the Group was ordered to the Surgeon General's Office, Washington, D.C., to confer with the Surgical Division of the Professional Service Section for the purpose of selecting the medical officers to be assigned to the Group. The professional qualifications of all medical officers suitable for such an assignment were studied. The officers possessing the required qualifications were made available, except officers on duty with the Air Force, those assigned to affiliated hospital units unless they constituted an overstrength, and those officers already overseas. Brigadier General Fred W. Rankin, Director, Surgical Division, Surgeon General's Officer, directed the assignment of the medical officer personnel. An analysis of the officers selected to head the surgical teams at the time of departure for overseas service reveals the following information: The average age of the team heads was 34 years; each averaged four years of postgraduate surgical training, three years of private practice and slightly more than a year of active military duty. Thus, the standards of surgical training among these officers was high.

b. Promotion.

The promotion of medical officers from the grade of captain to major should, it is believed, be based on considerations other than

T/O vacancies alone. It is suggested that an additional basis for promotion to this rank be considered including the length of military service and professional qualifications.

c. Rotation.

The policy of rotating a small percentage of personnel to the United States for reassignment is considered very desirable and has been practiced to the fullest extent possible by this organization. Likewise, these comments are appropriate concerning the policy of temporary duty in the United States for 30 days and the return of the individual to his organization overseas. The defects in the practical application of these procedures have, in our experience, been the following:

First, the quotas have been entirely inadequate. In particular has the officer personnel been unduly restricted in this respect. This organization has a larger number of officers than enlisted men, and special consideration is warranted in allotting quotas for officer personnel in an Auxiliary Surgical Group.

Second, the period which elapses before a replacement for the personnel rotated is received has been prolonged. For example, two officers left the Group on rotation in October 1943, and their replacements reported for duty March 1944, a lapse of five months. A similar situation exists relative to replacements for enlisted men. The requirement of not permitting the filling of the position vacancy created by rotation requires someone else to perform the duties of the personnel rotated without the possibility of promotion. This tends to lessen one's interest in doing a good job and has deleterious effect on morale. The requirement for eligibility for promotion requires the actual occupation and performance of the position for periods often of less duration that that which usually results from doing the job while awaiting the arrival of a rotation replacement.

10. Health:

The health of the command is paramount in maintaining its efficiency and morale. During the period which this organization has been overseas every effort has been made to provide the officers, nurses and enlisted men with the most adequate medical facilities that could be maintained under field conditions. Constant attention has been paid to the problems of preventive medicine, malarial control, mess hygiene, sanitation, and venereal disease control. The low incidence of communicable diseases, venereal disease, and those maladies caused by insect vectors has attested to the effectiveness of this program. A unit dispensary was continually in operation at the Group Headquarters.

II Administration (Health, contd)

During the period 9 March 1943, to 31 July 1945, 1232 patients were treated in the unit dispensary. These patients received 3057 individual treatments. During the same time, immunizations were administered in the following numbers to members of the command: Typhoid - 755, Small Pox - 432, Typhus - 870, Tetanus - 349, a total of 2406 immunizations that were provided. Medical service was often extended to neighboring units who did not possess facilities of their own. These included patients from other American units, United Kingdom troops, Indian troops and South African troops.

The personnel of this command had 4428 hospital days during this period (Table I.). The most frequent cause for hospitalization was gastro-enteritis with recurrent malaria the next most common. Thirty-three of the personnel were treated or hospitalized for wounds received as the result of enemy action. Of these, 31 were returned to duty and two were transferred to the Zone of Interior. Three individuals were killed in action and one died of accidental causes. The greatest incidence of illness during the 30-month period was during the months of March and April 1944, with a corresponding increase in March 1945. Respiratory diseases and gastro-intestinal disorders were the most prevalent diseases in these periods. The health of the command was the best during the month of September 1944, with a total of 6.06% of the mean strength of the unit hospitalized. (Figure 97) During the period 15 August 1944, to 15 June 1945, the Group was separated into two functional units. In the Detachment that was employed in France and Germany and the portion that remained in Italy during that time, the most prevalent causes of illness in each case were gastro-enteritis and recurrent malaria.

During the 30-month period that the entire Group has functioned overseas, there have been 44 individuals returned to the Zone of Interior for further hospitalization. This group of patients consisted of 20 officers, 12 nurses and 12 enlisted men. Of these, nine were individuals who had arrived in North Africa on "D" Day, 8 November 1942, or shortly thereafter. The most frequent causes for return to the Zone of Interior were neuropsychiatric disorders and gestation, there being six each of such patients. Next in frequency were cardiovascular diseases of which there were five cases.

The strenuous effort that was placed on the education of the troops in the control of venereal disease is reflected in the low venereal disease rate of nine cases or <u>.01045</u> cases per thousand per annum for the entire 30-month period that this unit has been overseas. Of the total number of cases, there were one case of primary syphilis, five cases of gonorrhea and three cases of chancroid that occurred. The program for the control of venereal disease consisted of the employment of visual aids, training films and frequent informal discussions held during formations of the Medical Detachment. It has been the policy to always have available at any hour of the day or night a trained noncommissioned officer in attendance at the unit Pro Station. These attendants were thoroughly

schooled in matters relating to venereal disease control. Full advantage was taken of organized athletics, recreation and other elements of the Special Service and Information-Education programs offered by Army and the Theater Commands. It was felt that because many off-duty hours of the enlisted men were occupied by these diversions, they definitely aided in influencing the low venereal disease rate of the unit.

TABLE I

Incidence of Illness Requiring Hospitalization

Year	Month	Hospital Tot Days	Officers Number	Officers Days	Enlisted Men Number	Enlisted Men Days	Nurses Number	Nurses Days
1943	March	54	5	22	5	19	2	13
	April	109	14	57	12	28	6	24
	May	96	10	32	12	52	5	12
	June	232	10	90	9	136	1	6
	July	212	11	61	12	121	2	30
	August	78	2	15	17	53	1	10
	September	81	3	18	10	63	0	0
	October	72	3	23	5	23	1	26
	November	103	6	33	5	54	1	16
	December	124	5	40	8	70	1	14
1944	January	190	8	108	4	52	2	30
	February	260	16	103	16	130	6	27
	March	308	14	163	16	112	4	33
	April	339	12	167	12	115	7	57
	May	130	6	83	6	30	2	17
	June	90	3	42	5	36	1	12
	July	235	6	94	6	102	4	39
	August	164	6	35	9	92	7	37
	September	88	2	35	2	35	2	18
	October	111	6	43	4	45	3	23
	November	225	9	104	7	65	3	56
	December	103	4	48	3	48	1	7
1945	January	156	7	39	6	33	5	84
	February	212	8	109	6	71	4	32
	March	239	3	38	10	169	2	32
	April	97	4	56	8	29	2	12
	May	169	1	8	10	85	8	76
	June	93	3	24	5	21	3	48
	July	58	4	25	6	24	2	9
	Totals	4428	191	1715	236	1913	88	800

II Administration (Health, contd)

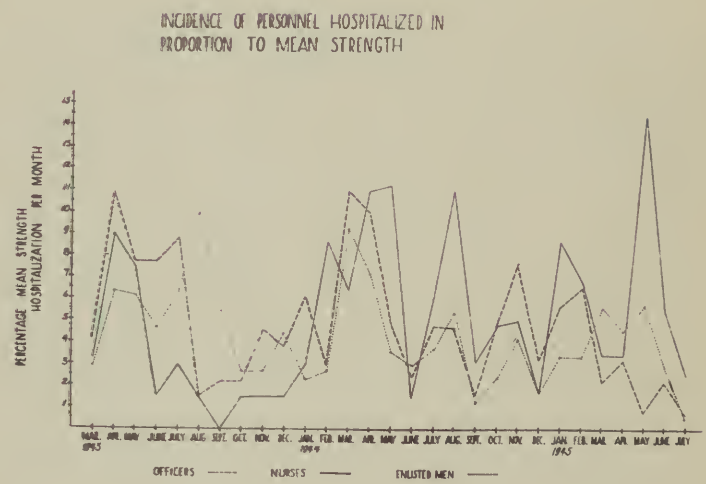


Figure 97 - Incidence of Personnel Hospitalized in Proportion to Mean Strength.

II Administration (contd)

11. Illustrations of Professional Service Forms:

a. Individual Case Record.

2ND AUXILIARY SURGICAL GROUP
APO 512, U.S. Army

Surgeon:__________ Date OP.__________ Hour______ Hosp______
Team:__________ NAME:__________ ASN:__________
AGE______ ORG:__________. INJURY: Date__________ Hour______
Type__________ Agent:__________
Sites of Injury__________
Time Lag__________ How transported:__________

PRIOR TREATMENT

Place	Time	IV Fluids	Sulpha po lcc.	Sedative	Prior Op.

PRESENT STATUS: Dehydrated ______ Nutrition ______ Disease ______
Conscious__________ Bleeding__________ Shock__________
Physical__________
Pertinent lab.__________
PREOPERATIVE TREATMENT:__________
OPERATION:__________

	PROCEDURE
Wound excision	
Debridement	
Chemotherapy	
Pack	
Drains	
Type closure	

P.O. DIAGNOSIS__________

ANESTHESIA RECORD

P L A N E A G E N T S

160
140
120
80
60
40
20
0

15 30 45 0 15 30 45 0

PRE-OP MED______ BP:______ PULSE______ RESP______ RISK 1 2 3 4
Duration__________ Technic__________ Anesthetist:__________
REMARKS__________

II Administration (Illustrations of Professional Service Forms, contd)

b. Follow-up Card.

Headquarters
_____________ Hospital
APO _____, US Army
Official Business

Commanding Officer
2nd Auxiliary Surgical Group
APO 512, US Army

Figure - Follow-up card placed in Record Jacket, MD Form 52d of patients evacuated to the rear after treatment by surgical team.

Patient:____
(Name) (ASN) (Org) (Team & No.)

TO: Surgical Service, Base Hospital, CZ.

We shall appreciate your cooperation in supplying the date asked for below at the time of final disposition of this patient in your hospital.

1. Complications:

2. Secondary Operations. Date:

3. Disposition: a. If ZI, date:
b. If RTD, date and class of Duty:
c. If died, date, primary cause, Post-mortem:

4. Remarks:

Kindly fill in, staple, and drop in the mail.
(Signed)__________________________ (Hosp.)______________________.

Figure - Reverse side of Follow-up Card that was filled out by base section surgeons and returned to the Group Headquarters to be filed with the operative case record of the patient.

II Administration (contd)

SUMMARY

The administrative requirements for the efficient functioning of an Auxiliary Surgical Group are manifold and exacting. As the professional qualifications for the medical officers are high an equally high standard of administration is mandatory if the Group is to render its maximum service. These matters of administration must extend into the details of military discipline, mess management, supply service, transportation and motor maintenance, personnel administration, supervised recreation facilities, as well as the fundamentals of other matters of military administration applicable to all military organizations.

All personnel engaged in administration functions should be cognizant and wholeheartedly devoted to the fundamental function for which the Group is intended. It is the duty of such personnel to make every effort to see that administrative requirements are fully met and in such a manner as to minimize any delays and difficulties which might divert attention from the organization's basic function. The varied and often wide dispersement of the personnel of the Group entails increased attention to the details of administration. Military discipline must be constantly inculcated in the minds and actions of all of its personnel. Much of the reputation and a great deal of the impression of the efficiency of an Auxiliary Surgical Group is obtained by the discipline displayed by its members. The fact that their employment is in installations in which they are not regularly assigned members of the staff, demands an alertness and display of even more exacting discipline than that of the intrinsic members of the unit in which they are functioning. A headquarters mess capable of accommodating fifty or four hundred persons on short notice requires ingenuity, adaptability, and minimal temperamental tendencies of mess personnel to warrant complimentary expressions for its members. A supply service which prides itself in readily furnishing the great variety of items from flashlights, to nurses' clothing, to anesthesia apparatus, and secures repairs of surgical instruments, cannot be idle if it anticipates these needs. The pay of personnel often employed in a dozen different and widely scattered areas, the regular and rapid distribution of mail, the maintenance of more than five times the amount of transportation originally allotted for the Group furnishes employment for enlisted personnel not actively engaged in team functions. The special requirements of furnishing proper recreational activities and the best possible living quarters under field conditions require constant diligence and ingenuity. Thus, the functions of Group Headquarters require a high degree of efficiency from all its personnel. The Headquarters must be located in close proximity to the teams and the installations in which they function. To meet these requirements a marked degree of flexibility in the organization is necessary so that it operates with such a smoothness that the varied duties performed are manifested only to those engaged in its operation. The Commanding Officer must maintain close and cordial relationship with the Commanding Officers and Chiefs

of the Surgical Service in which the teams of the Group are employed. His contact with the Army Surgeon and his staff especially the Army Surgical Consultant must be close enough to permit him to have knowledge of anticipated operational activities. The planning of higher headquarters which may require the employment of surgical teams requires that close liaison be maintained with the Theater Surgeon's office, especially with the Theater Consulting Surgeon "as recommendations regarding placement of teams, replacement of personnel, as well as surgical technics and procedures require close coordination with planning, movements of hospitals, and other items of theater policy." Inasmuch as these duties require that much time be spent in keeping close personal contact with his teams, the hospitals in which they function, and higher headquarters, it is mandatory that the Group Headquarters must be organized to function efficiently during his absence.

III. OPERATIONAL ACTIVITIES


THE HEADQUARTERS OF THE 2ND AUXILIARY SURGICAL GROUP
LOCATION
D-DAY LANDINGS
KAISERSLAUTERN MAR 29 1945
JAN.1,1945 SARREBOURG
DEC 8 1944 LIXHEIM
OCT 2 " EPINAL
SEPT 22 " VESOUL
LONS LE SAUNIER SEPT 12 1944
HARDHEIM APR 8 1945
SCHWABISCH HALL APR 25 1945
SCHWABISCH GMUND APR 27 1945
AUGSBURG MAY 4 1945
RIVA JUNE 9 1945
GARDA MAY 20 1945
MARSEILLES
MODENA APR 27 1945
PRATOLINA SEPT 21 1944
FIRENZE NOV 4 1944
POGGIBONSI SEPT 5 1944
SEPT. 4, 1944 ST. RAPHAEL
ST. TROPEZ AUG 15 1944
CECINA
FOLLONICA JUNE 30 1944
JUNE 11 1944
ROME
CARANO MAY 28 1944
ANZIO - JAN 22
NETTUNO
MARCIANISE DEC 5, 1943
NAPLES NOV 22, 1943
PAESTUM SEPT. 9, 1943
ALGIERS NOV 8, 1942
RABAT MAR 20 1943
CASABLANCA MAR. 9, 1943
ORAN MAY 13, 1943
CONSTANTINE JULY 4 1943
BIZERTE JULY 14 1943
GELA JULY 10, 1943
MOROCCO
ALGERIA
TUNISIA

Figure

III. OPERATIONAL ACTIVITIES.

1. General.

Throughout the overseas history of this organization the Group has been very much a part of the operational activities of the Medical Department in NATOUSA and MTOUSA, and to a lesser degree in ETOUSA while functioning with the Seventh Army in France and Germany. These activities have been evidenced not only in the amphibious operations of NATOUSA and MTOUSA, but also specifically with the Fifth and Seventh Armies.

In general, the phases of the operational activities of this Auxiliary Surgical Group functioning with an Army will be discussed under the headings of the various campaigns in which this organization has participated. In addition, note will be made of specialized types of military operations requiring the services of elements of this Auxiliary Surgical Group. Before describing these details of the operational activities of this Group a brief discussion of the factors which have governed these activities while functioning with an Army will be presented. These factors concern themselves principally with the organization of the medical service of a field force relative to the surgical management of battle casualties in an Army.

2. Triage of Casualties at Division Clearing Station.

The function of the division medical service includes the evacuation of casualties from its area. The division clearing station is the hub of the installations through which the casualties are evacuated. Repeated experiences of surgical teams functioning in division clearing stations have confirmed the inadvisability of using a clearing station for a surgical hospital. The single exception has been the employment of surgical teams from this Group in division medical installations during the early phases of amphibious operations when the facilities of a Field or Evacuation Hospital were not available. Even in amphibious operations, surgical teams are much better able to perform their function when attached to Field or Evacuation Hospitals which land during the first 24 hours. Our experience has repeatedly demonstrated that approximately eight percent of the casualties reaching the clearing station must receive surgery at this point in the chain of evacuation if they are to be afforded the best chance to recover. Certain facilities are essential for the care of such patients and the farthest point forward at which initial surgery can be well done is where these essentials can be assured. They include:
(Circular Letter No. 18, Office of the Surgeon, NATOUSA, dated 14 June 1943)

(1) An experienced surgeon, anesthetist, and operating room personnel.
(2) Simple, but adequate operating room equipment.
(3) Adequate lighting and water supply.
(4) Good, but not necessarily female nursing.
(5) Proper facilities to retain more seriously wounded patients 10 to 14 days.

Operational Activities (Triage of Casualties at Division Clearing Stations, cont'd).

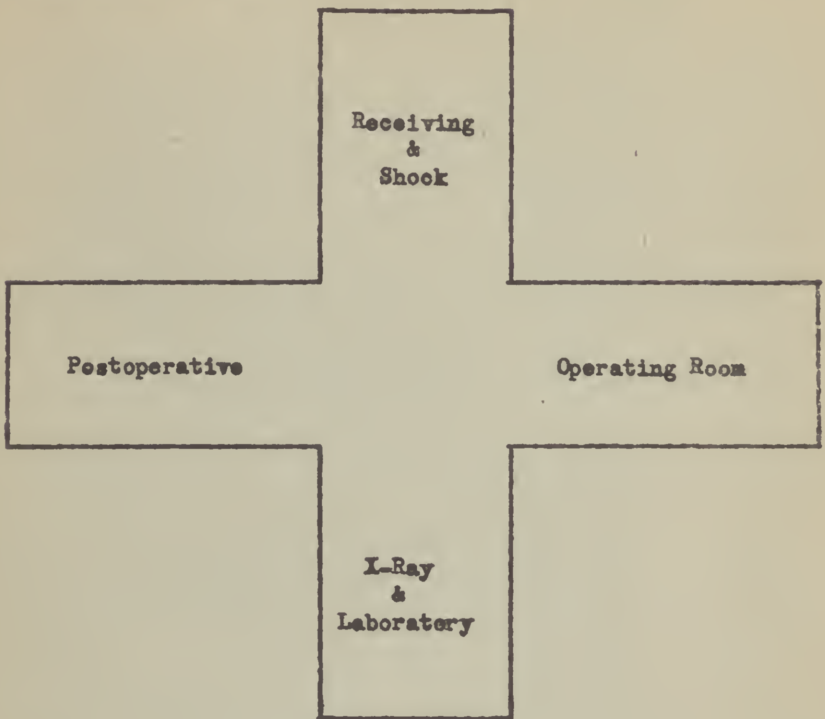
These facilities have been made available in NATOUSA and MTOUSA, and in the Seventh Army by utilizing platoons of a Field Hospital as small mobile surgical hospitals set up immediately adjacent to the division clearing station. Thus, the division medical service has immediately available a hospital to care for the casualties from its area who cannot be transported further to the rear without surgery. A division clearing station becomes, as Churchill has described, "The focal point of triage based on surgical urgency of the wound". The casualties arriving at this station are sorted into two principal categories; those who cannot be safely transported further to the rear without surgery (non-transportable), and those that may be safely transported further to the rear, i.e., to Evacuation Hospitals for initial surgery. This sorting is an important function of the division medical service.

3. First Priority Surgical Hospitals. (Platoons of a Field Hospital).

This small mobile surgical hospital was developed as an outgrowth of the experience of employing surgical teams of this Auxiliary Surgical Group in clearing stations. As noted above, the clearing stations are not suitable nor intended to perform the function of a first priority surgical hospital. In the Sicilian campaign, the platoons of two Field Hospitals (10th and 11th) were employed as priority surgical hospitals in which the Auxiliary Surgical Group teams were charged with the surgical management of the battle casualties. This short campaign demonstrated the feasibility of such a plan which was fully developed during the early campaigns in Italy. It is of first importance that these installations be able to move quickly in their organic transportation and be able to accept patients within two hours after arrival at their new site. To meet these requirements, the Field Hospitals functioning in such a capacity have had to be revamped. Additional transportation for each platoon was a prerequisite. The bed capacity for each platoon was decreased from 100 to a patient capacity of approximately 50. The surgical management of the casualties is a responsibility of the Auxiliary Surgical Group teams functioning in the hospital.

The physical setup of these first priority surgical hospitals when quartered in tents has been developed through extended experience and has become largely standardized. It is so erected in ward tents that the receiving ward, shock ward, operating room, postoperative ward, X-ray and laboratory form a cross. The receiving and shock ward is situated at the main entrance, the postoperarative ward occupies the tent which is a prolongation of the shock tent, while the X-ray and laboratory occupy a tent opposite to the operating room. A pyramidal tent forms the central point in the cross.

Operational Activities (First Priority Surgical Hospitals. (Platoons of a Field Hospital), cont'd).



This compact arrangement enables more efficient care of the patients, conserves the personnel requirement for the hospital, improves facilities for heating, eliminates the necessity for transporting patients from one tent to another in inclement weather, and enables an efficient blackout.

When these hospitals are set up in buildings, the problem is one of adapting the physical characteristics of the building to the functional needs of the hospital. Sometimes this is easy, at other times, tentage is more efficient than buildings.

Figure 99. A Field Hospital Platoon, Italy.

The postoperative nursing care is a function of the nursing personnel regularly assigned to the hospital. The regularly assigned medical and medical administrative staff are fully occupied with the administrative operation of the hospital. One exception is that the medical officers, other than the commanding officer, have been actively engaged in aiding the shock officers of Auxiliary Surgical Group shock teams and the surgeons in the management of shock.

The first priority surgical hospital is located at the rear of the division boundary, and is often set up in physical conjunction with the division clearing station. In general, three actively engaged divisions require six platoons (2 Field Hospitals) of priority surgical hospitals to provide adequate surgical care for non-transportable battle casualties. During periods of rapid tactical advances, these platoons "leap frog" one another in keeping up with the advancing front. The platoon left behind becomes a "holding unit", charged with the responsibility of the postoperative surgical care of the patients. This

Operational Activities (First Priority Surgical Hospitals. (Platoons of a Field Hospital), cont'd).

holding period varies, but usually lasts about 10 days. One surgical team usually remains with the holding unit. Not infrequently, major surgical procedures are required during this period, and always there are many problems arising in the postoperative care which tax the surgical judgment of the most able surgeons. As soon as all of the patients are evacuated, the holding unit becomes the platoon ready for an assignment forward, and again is set up adjacent to the division clearing station.

To state that no defects in the scheme of operation of a priority surgical hospital have been experienced would be inaccurate. The fundamental principle for which it was conceived in the surgical management of non-transportable battle casualties is sound, and any defects are not involved in this basic principle. The defects are concerned with the living conditions which have often been experienced in these hospitals. These conditions must at times, especially during periods of rapid movements, be meager for comfort. However, under more stable situations, the living conditions can be made very pleasant. The messing facilities have in general been found to be poor in these hospitals. These factors have a great influence and properly so, on the morale of the surgical teams functioning in these installations, which in turn may indirectly effect the care of the patients. These defects are readily correctable as has been repeatedly demonstrated when tactful, energetic, wise platoon commanders are placed in charge of such platoons. The position of a platoon commander of a Field Hospital is a very important one, and the proper selection of the officer for this job requires great care for, and appreciation of his duties. The solution to this problem lies basically in the selection of proper medical officer for the position of platoon commander and not in attempting to make a new or different hospital to serve the purpose of treating first priority surgical battle casualties under the conditions which this Auxiliary Surgical Group has experienced in Europe.

4. Role of Auxiliary Surgical Group Teams in First Priority Surgical Hospitals.

It is in this small forward mobile surgical hospital that teams of this Auxiliary Surgical Group have been extensively employed. They have been charged with the entire responsibility for the surgical care of the wounded treated in these hospitals. A senior surgeon from among the team personnel has been designated as the officer in charge of the professional work and responsible to the commanding officer of the hospital for its proper execution. During the last phases of the Italian campaigns, this plan was somewhat altered. One surgeon from a surgical team was relieved from his team duties and designated as chief of the surgical service in each active platoon. He functioned as a coordinator of the teams activities and was especially valuable, at this time, as several teams from base hospitals functioned for the first time in these priority surgical hospitals. Whether or not this arrangement is desirable under different conditions is, at present questionable.

Operational Activities (Role of Auxiliary Surgical Group Teams in First Priority Surgical Hospitals, cont'd).

In general, a busily engaged platoon required four to six general surgical teams and one shock team. A thoracic surgical team capable of doing general surgery should, if available, be included as one of the teams functioning in a platoon. These hospitals are simply but adequately equipped to furnish all the essential for good surgery. Whole blood is supplied through the facilities of a blood bank operated in a base section. Folding cots provide adequate beds and improvised head rests are used as indicated. The surgical teams furnish their own instruments and each team has a complete set of surgical instruments. To visualize a tent operating room in these hospitals, one sees a long, often double ward tent, with usually three operating tables. These tables are generally hand made wooden ones, or litters across iron or wooden "saw-horses". Sheets strung from a wooden frame form the partitions between the operating pavilions. On the opposite side of the tent is the sterilizing equipment which is in almost constant operation. The traffic through the operating room is often heavy and the activity is continuous until all the casualties requiring surgery have received treatment.

The comment of the Consulting Surgeon, MTOUSA, Colonel Edward D. Churchill, (Annals of Surgery, Vol. 120, September 1944 p. 271) is appropriate for describing the work of the Auxiliary Surgical Group in these first priority surgical hospitals.

"Surgeons assigned the responsibility of caring for the wounded in a first priority surgical hospital must be highly trained and experienced as their tasks are the most exacting of military surgery. The Auxiliary Surgical Group has been found ideal as a source for this personnel. The experience of the individual surgeon is augmented in the base during periods of an inactive front. Unity and uniformity in this portion of forward surgical personnel has produced a high level of competence as well as economy in the deployment of specialized surgical skill and talent. If the achievements in this theater are ever judged noteworthy, they are attributable to the fact that expert rather than inexperienced surgeons are doing the work. All other measures are ancillary items".

5. Role of Auxiliary Surgical Group Teams in Evacuation Hospitals.

From the division clearing stations, the transportable casualties are transported to the Evacuation Hospitals. These installations care for the great bulk of the casualties, approximately 90%, and the amount of surgery performed is great. The type of surgery differs considerably from that performed in the platoons of Field hospitals as the number of abdominal wounds and severe thoracic wounds form a small percentage of the total number of casualties treated. The percentage of patients suffering from soft tissue injuries, fractures, less severe thoracic, and head injuries constitute the great bulk of casualties. During busy periods these installations require surgical teams to supplement their staff. In fact, our experience has been that all hospitals

doing surgery in an Army require surgical teams from an Auxiliary Surgical Group when the fighting activity is great. It is in the Evacuation Hospitals that the specialty surgical teams find their greatest usefulness in an Army. The need for general surgical teams in these installations has been definite, but in general, less urgent than for the specialty teams.

6. Operational Activities During The Campaigns In Which This Organization Participated.

a. General.

During the earlier campaigns in NATOUSA, the surgical teams participating in the campaigns functioned at great distance from the Group Headquarters. In fact, during the Algeria-French Morocco part of the Tunisian campaign, the Group Headquarters had not arrived in the Theater, and could not exercise control over the activities of these teams nor render them assistance. The Group Headquarters and the major portion of the organization arrived in NATOUSA 9 March 1943. Earlier detachments had arrived on 8 November 1942 and 19 November 1942. No formulated plans had been established for the proper functioning of an Auxiliary Surgical Group in this Theater prior to the arrival of the Group Headquarters in NATOUSA. The many problems encountered in the successful performance of its mission required proper employment of highly trained surgeons, unusual tact, foresight, common sense, and energetic effort. As a result there was gradually evolved a method for the use and control of an Auxiliary Surgical Group which has proven highly successful and is detailed in this report.

b. Algeria-French Morocco Campaign (8 November to 11 November 1942).

The preparations made for the utilization of surgical teams of an Auxiliary Surgical Group in the Algeria-French Morocco campaign were, from the experience of this group, entirely inadequate. In fact, there appears to have been little detailed planning in this respect except that surgeons would participate early in the landing phase of the campaign. The 2nd Auxiliary Surgical Group was in the process of being formed at Lawson General Hospita, Atlanta, Georgia, in the early part of September 1942. A total of ten medical officers, three dental officers, two medical administrative corps officers and 66 enlisted men constituted the personnel of the unit at that time. None of the enlisted personnel was a qualified surgical technician.

(1) First Detachment of Teams Ordered Overseas.

Orders were received 15 September 1942 for two general surgical teams, one orthopedic surgical, and one shock team, (a total of

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

eight medical officers, four nurses, and six enlisted men) to report to the New York Port of Embarkation, New York, by 16 September 1942. It is evident from the above strength report that nurses were not present. Sufficient qualified medical officer personnel and enlisted men required to constitute these teams had not been assigned to the Group. These demands were partially met by assigning to the teams the qualified officers who were present, and obtaining orders from the War Department for qualified officers available in the Medical Department Replacement Pool at Lawson General Hospital to be assigned to the Group for duty with these teams. Still the requirements could not be met and one officer and four nurses were ordered from other stations to join these teams at the New York Port of Embarkation. Thus, the personnel which finally comprised these teams had, in several instances never seen the other members of their team until they embarked from the New York Port of Embarkation. In fact, the detachment was never assembled as a whole until it landed in Ireland. The enlisted men were new recruits having been in the Army only eight weeks when they departed for overseas duty to perform a highly technical job. This is indicative of the state of planning and confusion of the early days of the war, for it is hardly conceivable that such a hurridly constituted detachment of teams could be expected to work immediately either as a well coordinated group, or as individual teams. These teams left New York 25 September 1942 and arrived in Northern Ireland early in October 1942. They remained there approximately three weeks. The nurses were replaced by six additional enlisted men, three of whom were well qualified surgical technicians. The detachment of teams was attached to the Eastern Task Force to function with the 39th Combat Team for the forthcoming invasion of North Africa. They departed from Ireland 24 October 1942. The nurses of this detachment never rejoined the 2nd Auxiliary Surgical Group.

The activities of this detachment of teams, which will be detailed presently, and those of a second detachment of teams which arrived in North Africa on 18 November 1942, portray some of the difficulties encountered during the early campaigns. However, the early experiences of these teams in the surgical management of severely wounded battle casualties were of greatest value in later formulating an efficient organization for the operational activities of this group in the subsequent campaigns. Their experiences proved that the Group Headquarters or a detachment of the headquarters should be made available to any sizable detachment of teams which might be required to function at an inaccessible distance from the remainder of the group. They likewise emphasized the need for a proper installation in which major surgery could be well done in areas forward of the Evacuation Hospital. These factors have been overcome in subsequent similar campaigns by having the Group Headquarters or a detachment of the group headquarters located in close proximity to the teams. The development of the present small mobile first priority surgical hospital was in a large measure an outgrowth of the early experiences of the surgical teams of this group.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

The extract of the report which follows is from Major Paul L. Dent, M.C. (then Captain) operating surgeon of a general surgical team of this organization which became the first surgical team of an Auxiliary Surgical Group of the United States Army to ever function in an active Theater of Operations.

"On November 8, 1942, the 39th Task Force, part of the 9th Division anchored off Charley Red Beach near Surkouf, thirteen miles east of Algiers about 1:00 A.M. The Navy Medical personnel set up an aid station on the beach after the beachhead was secured. The plan was to evacuate casualties to the ships until it was thought safe to land a clearing station. This plan was never carried out because the sea was too rough to land equipment. At 1:00 P.M., 8 November 1942, the ship received a radio call to send medical personnel ashore. Captain Dent and Captain Mansfield were asked to go ashore and determine what medical equipment was needed. We landed about 4:00 P.M., but were never able to contact the ship again, due to roughness of the water. No more landing barges were dispatched. Captain Mansfield and myself assisted the Naval personnel in the Aid Station Sunday evening and night 8 November 1942. The only supplies available were dressings and morphine. We could not evacuate casualties to the ship and had no instructions from the Task Force Surgeon as to the disposition of them on land by the morning of 9 November 1942. We evacuated some twenty odd patients to the dispensary of the Air Field, Maison Blanche fifteen miles southeast of Algiers, by truck and French ambulances. We were no better off here in the way of equipment, but did have a building, and Captain Mansfield and myself had to do the cooking, feeding and complete care of the patients. Not having received any instructions, we loaded the casualties in French ambulances and Captain Dent rode with them through the lines to the French Army Hospital in Algiers. After explaining our situation, the French Commadant was very sympathetic and promised to care for our casualties until our own medical installations could be landed and set up. We evacuated to the French until Wednesday night, 11 November, averaging about twenty to thirty casualties a day, mostly from the heavy bombings of the air field where we were located......."

"Our ships docked at Algiers on the evening of 11 November, and we set up in a school building in Maison Carree, with Captain Yancy's Clearing Station. Our two general surgical, and one orthopedic and one shock team did our first surgery here, on 12 November 1942".

As noted in this report there were no installations available which furnished the hospital facilities needed for the proper functioning of surgical teams of an Auxiliary Surgical Group. Also, a period of three days elapsed after the landing before the teams did any major surgery.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd.)

Qualified surgeons and surgical instruments are entirely inadequate unless proper facilities are made available to care for the patients before and after surgery. The Algeria-French Morocco campaign terminated 11 November 1942. The experiences of this detachment of surgical teams continued through the Tunisian campaign.

(2) Second Detachment of Teams to go Overseas.

On 6 October 1942 an alert order was received at Group Headquarters, Lawson General Hospital, Atlanta, Georgia, for eight general surgical, three orthopedic and three shock teams to arrive at the New York Port of Embarkation 10 October 1942. As it later developed, these teams were the reserve to be employed in the Algeria-French Morocco campaign if needed. Fortunately, the campaign was very short and their services were not needed in that campaign. A presentation of their operational activities from the time they left the Group Headquarters until the entire organization arrived in NATOUSA will be outlined.

By the time the alert order arrived at Group Headquarters, the T/O medical officer strength of the unit had been almost filled. Unfortunately, there had been no opportunity for any unit training for the officers. There were no nurses present and no qualified surgical technicians. Thus, to comply with this order it required that surgical technicians be selected from functioning hospitals. This was accomplished by ordering forty-two qualified and experienced surgical technicians from various hospitals of the Fourth Service Command to join this unit for duty with the alerted surgical teams. Nurses did not accompany this detachment of surgical teams and each team had an additional enlisted man in lieu of an operating room surgical nurse. This detachment, without an administrative headquarters, departed from Group Headquarters, Atlanta, Georgia, 8 October 1942 for Camp Kilmer, New Jersey.

On arrival at Camp Kilmer, they were attached to the 8th Evacuation Hospital. On 2 November, they sailed with the 8th Evacuation Hospital aboard the "Santa Elena". This vessel joined the convoy of the Western Task Force enroute to Casablanca, French Morocco. The vessel became part of the D-5 Convoy. On 11 November 1942, the news of the capitulation of the French forces in North Africa was joyfully received. The harbor at Casablanca had been damaged and for the following seven days, the ships in the convoy cruised off the coast of Northwest Africa. The ship carrying the teams and the 8th Evacuation Hospital docked at Casablanca 19 November 1942. The casualties from the campaign had been light and the surgical teams were not needed. For the following four months the major portion of this detachment remained with the 8th Evacuation Hospital at Casablanca. The hospital functioned, but was not particularly busy and did not need the assistance of the surgical teams. These four months were very trying days for most of the detachment. They had no administrative headquarters and their only professional work in Casablanca consisted in operating a venereal disease section of the 8th Evacuation Hospital.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

c. Tunisian Campaign (17 November 1942 - 13 May 1943).

The Tunisian campaign was a long, bitterly fought series of battles in which American forces were very limited in experience and numbers. During these early days, many of the problems which must be met in the successful operation of teams of an Auxiliary Surgical Group became apparent. The mass of details, plans, and decisions necessary to insure the efficient functioning of such an organization, was brought forcibly to the attention of this organization during the period of this campaign.

Near the beginning of the Tunisian campaign there were ten general surgical, four orthopedic surgical, and four shock teams of this Group in North Africa. Early in January 1943, three general surgical, one orthopedic and two shock teams were functioning with the II Corps (U.S.), the headquarters of which was at that time in Constantine, Algeria.

The Allied troops had advanced into Tunisia on 15 November 1942, after securing Morocco and Algeria. They drove east for Tunis and Bizerte but were halted less than 50 miles from these two big ports and forced to withdraw into Algeria. One surgical and one shock team of this unit were with the forward elements of a British Casualty Clearing Station when the Allies penetrated into Tunisia.

Further extracts from the report of Major Paul L. Dent referred to above are quoted, and indicate the nature of the operational activities of the surgical teams during this period. His team participated throughout the Tunisian campaign:

"January 10th, 1943, we proceeded to El-Guerrah to report to the U.S. Army Hospital located there. On arrival at El-Guerrah, no American medical installation was found. Inquiry revealed that there was one at Telergma. We proceeded there and were told that their orders to set up in El-Guerrah had been cancelled two days ago and that they were waiting for new orders. We proceeded to Tebessa and bivouacked in Tebessa Heights five miles past the town. We performed two major operations at this place".

"January 21st 1943, we were ordered to proceed to Sbeitla where we set up with the 16th Clearing Platoon. The majority of the medical personnel were uncooperative and seemed to think that we were depriving them of their just dues. We managed to iron out the difficulties without too much trouble. Work here was sporadic and consisted mostly of road accidents and casualties from strafing and bombings. We were working under very difficult conditions here. The wind blew sand and dust through the tents constantly, the lighting system gave out usually in the middle of operations, which had to be finished with

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

flashlights or lanterns. Our trouble with the heating units for sterilizers and autoclaving was ever present".

"January 31st, 1943, we were attached to the 16th Medics and directed to go to Gafsa where we would receive further orders. After driving all night we arrived in Gafsa at 5:10 A.M. We were ordered to remain in the outskirts of Gafsa until the situation clarified itself. We tried to sleep but between the wind, sand and air raids, this was impossible. In the late afternoon, orders came for us to move up with the 47th Medics who were supporting the First Armored Division and part of the 168th Infantry attempting to take the town of Sened. The platoons of the 16th Medics and our group contacted the 47th Medics and set up with them about four miles behind the fighting line. We began work immediately, getting about nine hours sleep in four days".

"We received orders to retreat at 7:15 P.M. February 4th, as our troops were being pushed back. We were five hours traveling eighteen miles as the roads were crowed with tanks, guns, etc., falling back. We were pulled back to Tebessa Heights to the 16th Medical Battalion Headquarters and bivouacked for ten days while the II Corps reorganized."

"February 14th, 1943, we moved to the French Barracks at Ferriana and were attached to the 1st platoon, Company "D" of the 51st Medical Battalion. The personnel of the company were very cooperative and helpful. We began work at 7:30 A.M. February 15th 1943. After completing three cases we were informed that we were three miles in front of our own lines. Headquarters got through to us with an order to fall back to the top of the mountain, thirteen miles west of Thelepta, and bivouac. We were here until 6:30 A.M. February 17th when we received orders to fall back 2½ miles further to Bou Cheleka. Here we set up two ward tents, one for admission and shock and one for surgery. We operated on occasional cases, but not enough to keep busy. The only unit in front of us was the 1st Ranger Battalion of 60 enlisted men and three officers".

"February 20th, 1943, we were ordered to move back eight miles further. February 25th 1943 we moved ten miles east of La Meskiana to bivouac. While resting here, equipment was cleaned and washed, vehicles repaired and everything readied. We really appreciated the pyramidal tent and stoves that Major Dent procured in Oran. There was almost constant rain and snow".

"On March 15th, 1943, after 19 days of inactivity, we were ordered to move to a location a few miles west of Bau Chopeta. March 18th 1943 at 7:30 A.M. we moved to the vicinity of Gafsa on the road to El Guettar, but had to go back almost to Ferriana because the raod from Moulares to Gafsa had not been cleared of mines. Heavy rains

welled the roads with water and several of the vehicles became bogged down and had to have assistance. We arrived in Gafsa at 5:00 P.M. March 18th 1943. Orders were that we go to Gafsa and if the liaison officer did not contact us there to continue on to an olive grove two miles west of El Guettar. Enroute we were stopped by a Colonel who inquired where we were going and what unit we were. On being informed, he laughed and said that we 'must be a damn tough bunch of medics'. On being asked if we spoke German and receiving a negative reply he informed us that we had better return to Gafsa because the olive grove for which we were headed was at the moment inhabited by Germans and that he was organizing a patrol at dusk to rout them. We returned to Gafsa and bivouacked in a building across from the railroad station. While at Gafsa we were bombed frequently. On two nights the raids were practically continuous, many antipersonnel bombs being scattered over the area. Little damage was done excluding the window panes. Colonel Forsee, Commanding Officer, 2nd Auxiliary Surgical Group arrived in Gafsa during our stay there and informed us of the arrival of the entire Group in the Theater. We were anxious for news of the group and happy that our headquarters would take over the control of our team.

"April 11th 1943, we moved to Ferriana. We convinced Ordnance that a C & R was more appropriate for us than a truck, so we affected a trade. Now we have a two and one-half ton truck and a C & R. April 14th, 1943, we left Ferriana and moved to the vicinity of Sauk-El-Kemis by way of Tebessa, Le Kouf and Le Kef and Souck-El-Arba. We arrived at our bivouac area ten miles north of Souk-El-Kemis at 5:30 PM. While here, we paid a visit to the 1st C.C.S. to look up old acquaintances".

"We moved twice between April 15th and 21st. On the latter date the 15th Evacuation Hospital set up adjacent to our bivouac site. This was the first hospital of this type which we had seen. We moved over and started to work doing mostly minor injuries, some of which had been in the hospital for thirty-six hours and were frankly infected. We worked here April 24th and 25th, doing approximately 26 cases. No work on 26th and 27th.

"May 8th, 1943, orders attached the 1st Platoon of Company "D" of the 51st Medical Battalion and our surgical and shock teams to the 9th Division Medics and we were ordered to bivouac on the Djebel Afoid-Dedjeome-Bizerte road about 15 miles west of Ferryville. Bizerte and Tunis fell to us on May 8th, 1943 at 3:30 and 4:20 P.M., approximately. No method nor facilities were available to care for the thousands of Axis prisoners, many of whom were injured and sick. The 1st Platoon of the 51st Medical Battalion, with our surgical and shock team was ordered on May 10th, to set up in the barbed wire prison stockade four miles west of Mateur. There was no work to be done there, as all injured prisoners were evacuated to the 9th Evacuation Hospital for care".

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

"May 12th, 1943, we received orders to rejoin the 51st Medical Battalion located two miles west of Mateur and go into bovouac. We remained here until 16 May 1943 when orders were received detaching us from II Corps and ordering us to return to our own headquarters, location unknown. Information received from Colonel Churchill of AFHQ, Algiers, was that the Group Headquarters was in the Oran area, but we did not know the exact location. Location was unveiled to us by the Mediterranean Base Section Surgeon in Oran. We reported to Colonel Forsee at 2nd Auxiliary Surgical Group Headquarters on Goat Hill, one mile north of Assi Ameur at 6:20 P.M., 20 May 1943".

The problems of a strictly professional nature encountered during these early days were great when compared with the high standard of the facilities available to the surgical teams of this Group during the later campaigns in Italy, France, and Germany. These excerpts from reports of Captain William Weiss (anesthetist) and Captain William Mansfield (assistant surgeon) members of Major Dent's surgical team are of special interest:

"Anesthesia was ether or sodium pentothal. No gases were available".

"Postoperative care was lacking. There were no trained personnel, no facilities for intravenous fluids, no food for patients except "C" rations, no facilities for transfusion of whole blood, except the blood received from military donors, and there was no way of checking such blood for the presence of malaria or syphilis. Patients were evacuated as rapidly as possible, the majority in six to eight hours postoperatively, some after they had reacted from the anesthesia and some while still under anesthesia. The latter seemed best suited for abdominal cases".

Among the 175 patients treated by Major Dent's team (records on an additional 125 cases treated during the period of November and December were lost by enemy action) the location of the injuries among the casualties treated were as follows. The types of injuries treated are in marked contrast to those treated by surgical teams of this Group functioning in first priority hospitals in Italy, France and Germany:

Head	29
Neck	5
Thorax:	
Chest Wall Only	14
Sucking	8
Ribs	4

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

Abdomen:	
Abdominal Wall Only	7
Intra-abdominal	17
Soft Tissue	103
Fractures, compound excluding fingers and toes:	
Upper Extremity	13
Lower Extremity	30
External Genitalia	5

The following excerpt from the report of another general surgical team which functioned with II Corps for four months in the Tunisian campaign emphasises several points presented in the foregoing report. (Extract from report of Major Robert O. Garlinghouse).

"One hundred and nineteen days were spent in the combat zone. Of these the number of days in which the team was actively engaged was 71. The team traveled 2462 miles in 24 moves. We slept in pup tents from the middle of January to the 20th of March. The lack of organic transportation for each team was keenly felt during the entire period of activity of this team. The lack of a Group or detachment Headquarters in close prdximity to the teams functioning in the forward area was a great handicap. The full and earnest cooperation of II Corps Surgeon and his staff was enjoyed by all the surgical teams working in the forward area, and this fortunate situation stood us in good stead throughout the long months of the winter campaign".

The following extract from the annual report of the Consulting Surgeon, NATOUSA, 1943 (Colonel E. D. Churchill) relative to the Auxiliary Surgical Groups is as follows:

"It is impossible to overestimate the contribution to surgical standards in the Theater made by members of the Auxiliary Surgical Groups. The distinguished history of these organizations will be recorded independently, but certain observations from the perspective of the Theater as a whole deserve special comment. It is one thing to describe the organization of the Group, its mission in general terms, and quite another to visualize the actual work of a single team. At the time of the initial landing and later during the early phases of the Tunisian campaign, the members of the Detachment of the 2nd Auxiliary Surgical Group were scattered here and there living the life of gypsies. There were no precedents that established their mission, no plans that defined the policies for forward surgery, and no adequate facilities for performing surgery in the combat area. These highly trained surgeons were transferred from one unit to another without explanation or designation of their function, bivouacked in pup-tents throughout months of cold and rainy weather and begged for transportation

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

necessary to carry out urgent orders. Their surgical skill saved many lives but in addition, they nursed and at times prepared food for their patients, cut firewood to keep them warm, rode with them as attendants in ambulances, laundered and resterilized essential surgical linen, improvised surgical equipment, working not only under trying conditions but frequently exposed to enemy bombing and strafing as well as the hazards of an inadequately defended and shifting defense line".

(1) Departure of Group Headquarters and the Main Body of Teams for Overseas.

On the 21st of February 1942, the main body of the 2nd Auxiliary Surgical Group moved from Lawson General Hospital, Atlanta, Georgia, to Camp Kilmer, New Jersey to embark for overseas duty. About one week before, approximately 20 qualified surgeons had been transferred from this group to the 1st and 4th Auxiliary Surgical Groups to form the nucleus of those two organizations which had recently been activated. It was a very pleasant privilege to have several of these former members of the Group to again function under the control of this organization from December 1944 to May 1945 in France and Germany while they were members of the 1st Auxiliary Surgical Group. All of the members of the Army Nurse Corps assigned to the Group, except four, who were with the Group at Lawson General Hospital, Atlanta, Georgia, had been ordered to Camp Kilmer, New Jersey, to await the arrival of the organization at this embarkation point.

On the 27th of February 1943, the Group boarded the H.M.T. "Andes" and sailed unescorted from the New York Port of Embarkation the following afternoon. The strength of this Group was as follows: 93 Officers, 66 Nurses, and 139 enlisted men. The voyage was uneventful and the Group disembarked at Casablanca, French Morocco, the 9th of March 1943. The personnel were temporarily quartered in local hotels, school buildings, and tents. On 20 March the Group Headquarters was established in tentage about one and one-half miles from Rabat, French Morocco.

On the arrival of the main body of the organization, the two previously arrived detachments reverted to the control of the parent Group. The location of these detachments at this time was as follows:

One general surgical team at Safi, French Morocco.
One general surgical team, one orthopedic surgical team at the 96th General Hospital (British), Algiers.
One general surgical team at the 31st General Hospital (British), Oued Athmenia, Algeria.
Three general surgical teams, II Corps (Tunisia).
One orthopedic surgical team, II Corps (Tunisia).
Two shock teams, II Corps (Tunisia).
Four general surgical teams, two orthopedic surgical teams, two shock teams, 8th Evacuation Hospital, Casablanca, French Morocco.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated cont'd).

During the first week in April, the Commanding Officer reported to the Theater Surgeon in Algiers and arrangements were made to visit all elements of the Group in NATOUSA. The Commanding Officer accompanied Colonel Edward D. Churchill, Theater Consultant Surgeon in inspecting all forward installations in which the teams were functioning. Upon the information obtained on this tour, much of the planning for the future employment of this Group was based.

In April, arrangements were made for several of the teams to immediately begin functioning in the British General Hospitals in Algiers and Tunisia. In April, nine surgical teams were placed on temporary duty with the 94th, 95th and 99th British General Hospitals in Algiers and with the 5th, 67th and 100th British General Hospitals in Bone and Phillipeville, Tunisia. The experience gained from the employment of surgical teams in these British Hospitals was very valuable. It was the first opportunity for the members of these teams to participate in the surgical management of battle casualties. The extended prior experience of the British surgeons in these hospitals was presented to the members of the surgical teams of this Group in a most interesting and pleasing manner. All of our work with the British has been characterized by pleasant associations. Also, one general surgical team and one shock team operated a provisional station hospital at Port Lyautey, French Morocco. Three dental prosthetic teams began functioning in the Mediterrean Base Section Dental Clinic at Oran, Algeria. Following the close of the campaign in Tunisia, 13 May 1943, all of the teams reassembled at the Group Headquarters in Oran, Algeria.

(2) Comment.

The Tunisian campaign served to provide the initial indications of certain requirements for the successful operation for this Group. Basically, the following recommendations were made and agreed upon. First, that sufficient transportation be added to enable adequate mobility of the teams. Second, that sufficient tentage be allotted for housing purposes. Third, that Group Headquarters be established in close proximity to the teams functioning in the forward areas. Fourth, that a clearing station is not a suitable installation for the surgical care of seriously wounded battle casualties.

In June 1943, Brigadier General Joseph I. Martin (then colonel) Surgeon, Fifth Army, visited Group Headquarters and tentative plans for the employment of the Group with the Fifth Army were discussed. He assured everyone that there was plenty of surgical activity in store for the Group.

d. Sicilian Campaign. (9 July 1943 - 17 August 1943).

Early in June, seven surgical teams, (six general and one orthopedic) were requested from this organization for the forthcoming missions of II Corps in the campaign for Sicily. These teams were carefully selected. Although detailed information was not available as to

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

the nature of the forthcoming operation, the plan as related to the surgical teams of this Group was briefly as follows: An amphibious operation was contemplated. The general scheme for the care of battle casualties on the beaches and afterwards involved the employment of the surgical teams of this Group in Field and Evacuation Hospitals and for a brief period in division clearing stations. Casualties encountered during the initial assault waves were to be evacuated directly to ships and cared for by Navy personnel. As soon as possible, probably on "D" day, a clearing station would set up on the beach with surgical teams attached to care for the seriously wounded casualties who could not be safely transported to the ships located offshore. The surgical teams would move to and function in Field Hospitals as soon as these installations could be brought ashore, probably "D" day plus two. Evacuation Hospitals were to be set up on "D" day plus four.

On 16 June 1943, this detachment of teams reported to the Headquarters, 1st Division (Infantry) near Oran and the following day moved to an assembly area at Staoueli, on the outskirts of Algiers. Five of the teams were attached to the 11th Field Hospital and two teams to a provisional Clearing, Collecting Company, 51st Medical Battalion. The latter unit was to function as a small surgical hospital on the beach. The detachment of teams started on 26 June 1943 from Algiers by L.S.T. to another staging area at La Goulette, near Carthage, Tunisia, arriving at this site 30 June 1943. Prior to embarking for the actual invasion operation the officers of the surgical teams were assigned to different ships in the convoy to act as ship surgeon during the trip. On 6 July all personnel boarded their assigned ships and embarked for the forthcoming invasion.

"H" hour was at 0245, 10 July 1943, and the firing of the Navy cruisers, flares and searchlights on the shore and enemy firing could be seen from the ships off shore. Between 0800 and 1400 hours on "D" day the surgical teams had disembarked and were ashore. The following extract is quoted from the report of Major Henry T. Ballantine Jr., surgeon in charge of one of the general surgical teams participating in this operation which functioned initially in a provisional clearing-collecting company.

> "At 0245 hours, 10 July 1943, after a rough crossing, our ship lay off the beach, rolling in a moderate sea. At 0830 hours we moved in toward the beach and unloading began. Air activity was moderate, but there was no enemy ground opposition at the time on the beach itself. At 1330 hours our personnel debarked to find that we had been landed in the 45th Division area and that eight and one-half miles, approximately, lay between us and our station site. The latter was reached about 1730 hours, progress being slow due to the difficulty of walking through sand, and the fact that the beach and the landing craft thereon were subject to repeated strafing. We reached our station site without casualty,

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

and were at this time about 3/4 mile from the water. The only equipment available was that contained in the $2\frac{1}{2}$ ton truck, which included the chests belonging to the surgical team. The next morning, the transportation began to roll in, but due to the possibility of a tank break-through by the Germans three miles away, it was felt advisable to delay setting up station until this threat had been removed. At about dusk the tents began to go up and patients began to arrive. Some had by-passed the clearing station entirely and received their first primary treatment here. By 2000 hours, the station was jammed and every effort was made to send any transportable patient to the ships. This team operated on five non-transportable cases in the following 24 hours and supervised the evacuation of about 100 wounded men. Surgical routine was interrupted by the presence of German planes over the beaches, and the efforts of German artillery to reach a gasoline dump in our rear."

"It was manifestly impossible to obtain blood in sufficient quantities at this time, and facilities for cross-matching or storage of blood were lacking. Also absent was any form of positive pressure anesthesia and there were no X-ray facilities whatever. Postoperative care was not as good as one could wish, due to the lack of trained personnel. The advantage of holding acutely ill postoperative patients was doubtful under this arrangement. It was quite apparent that a platoon of a Field Hospital was urgently needed if any surgery was to be done in the clearing station area, since such a platoon was equipped more fully for preoperative, operative and postoperative care. It should be emphasized that this need in no way reflects upon the personnel of the clearing station, but is intended to reemphasize a fact now well known, namely, that a clearing station cannot be readily equipped for definitive surgical care of patients. Furthermore, it should be noted that this principle applies just as readily on the beachhead as elsewhere and that a platoon of a Field Hospital should be able to accompany a clearing station on an amphibious operation. Under the circumstances, however, the degree of cooperation and service rendered the surgical teams by the clearing station to which they were attached was magnificent."

"By 13 July the 11th Field Hospital had set up in Gela, Sicily, and had taken over the function of a priority surgical hospital".

This campaign which lasted 38 days was characterized by rapid advances and fortunately fewer casualties than anticipated. It was during this campaign that the plan of utilizing platoons of Field Hospitals as first priority surgical hospitals functioning in conjunction with division clearing stations was formulated and put into action. The following extract from a report of Major Henry L. Hoffman, MC, surgeon in charge of a team participating in this early phase of the development of first priority surgical hospitals indicates the potential value of this plan.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

> "The greater part of our time in the field has been spent with platoons of the Field Hospital and I feel this is the ideal place for use of the surgical teams. Here the team functions as a unit; they supervise the shock therapy, do the surgery and postoperative care. The platoon has X-ray facilities which are of considerable value. The employment of nurses on the ward is of tremendous help to the patient as well as the team. A very important provision was the formation of a holding unit to keep patients until they were ready for evacuation. One team remained with the holding unit while the hospital and remainder of the teams moved on".

On 11 August, seven nurses departed from Group Headquarters, near Bizerte, to join their respective teams functioning in Sicily. These nurses accompanied their teams to Italy, landing at Paestum on "D" day plus six. One surgical, one shock, and one maxillo-facial surgical team functioned aboard the Hospital Ship Carrier "Lennister" (British) in caring for casualties transported from Sicily to North Africa during July and August 1943.

Although the surgical experiences of teams participating in this campaign were not as extensive as in later campaigns, several very valuable lessons were learned which emphasized these points. First, that whole blood was needed in large amounts for the early treatment of severely wounded battle casualties. Second, that the employment of Field Hospital platoons as first priority surgical hospitals set up at the rear of the division and devoted exclusively to the care of non-transportable casualties was feasible. Third, that the need of organic transportation for surgical teams was urgent.

Although recommendations for a detachment of the Group Headquarters had been made and tentative plans for the entire group to move to Sicily had been contemplated, the short duration of the campaign prevented its accomplishment. Again the lack of the availability of the Group Headquarters in the immediate vicinity of this campaign was keenly felt by the teams in Sicily.

In preparation for the Sicilian campaign, the Group Headquarters and all teams which had not departed earlier for the campaign moved from Oran, Algeria, to an area near Bizerte, Tunisia. This move placed the Group in an accessible location, should they be required in Sicily. It also placed them in the vicinity where they were most needed for the care of casualties returned from the Sicilian campaign. A plan for the employment of the Group in the hospitals of the Mateur, Tunis, Bizerte area was formulated which was put into execution on 10 July 1943 and proved very successful.

A unique situation presented itself in July, August, and September for the employment of the teams located in the above area. The

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

Sicilian campaign began 10 July 1944 and the ports of Bizerte and Tunis were the debarkation points for casualties from that campaign. Two 750 bed Evacuation Hospitals were functioning in this area and one General Hospital was soon put into operation. Thirty surgical and allied specialty teams from this Group were placed on tempoary duty at eight different Station Hospitals in the Bizerte-Tunis-Mateur area. Certain of these hospitals augmented by the general and specialty surgical teams of this Group were designated as centers to care for particular types of injuries such as chest, head and spine, severe extremity injuries, burns, and maxillo-facial. The utilization of surgical teams at this time and in the manner described provided expert surgical treatment for the casualties and afforded an excellent opportunity for the surgeons to gain experience and evaluate the surgical management of battle casualties in rearward hospitals. This situation did not again present itself in the experience of this organization as almost all of the employment was to be in the forward areas.

e. Campaigns in Italy, Southern France, and Germany.

(1) General.

This organization participated in all campaigns in Italy and based upon its work with the Fifth Army evolved the methods which are considered best for the Use and Control of an Auxiliary Surgical Group functioning in a field Army.

(2) Naples-Foggia Campaign. (9 September 1943 - 21 January 1944).

Preparation for the employment of surgical teams of this organization to function with the Fifth Army in the campaigns in Italy began about the middle of August 1943.

Two detachments consisting of five general surgical two orthopedic, and two shock teams were alerted for the forthcoming amphibious operations to be undertaken by the Fifth Army. The first detachment of teams left Group Headquarters, Bizerte, 26 August 1943. They traveled by train and joined the VI Corps in Oran, Algeria, 30 August 1943. The second detachment departed from Group Headquarters 2 September 1943 and arrived in Oran 6 September 1943 about the same time the seven surgical teams in Sicily were relieved from the Seventh Army and attached to the Fifth Army.

The first detachment of teams was placed aboard three different ships, the "John Stanton", "Orantes", and "Marnix", together with their equipment and set sail in the "D" day convoy for the forthcoming invasion. The nurse members of the teams had accompanied the detachment to Oran but were detained there and joined their respective

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

teams on "D" day plus 12. This detachment of teams landed on "D" day, 9 September 1943 at Paestum, Italy. During the first several days of this battle, which was doubtless the most difficult beachhead assault in which surgical teams of this Group have participated, they worked tirelessly and efficiently in performing expert surgery under the most difficult conditions of war. The following brief extract from the report of Major Frank W. Hall, MC, surgeon in charge of one of the surgical teams, describes the initial landing.

> "We sailed from Oran harbor with the invasion forces for the landing at Salerno Beach, Italy on 9 September 1943. Our boat stood approximately ten miles off shore at dawn and shortly after noon on "D" day we waded ashore from our L.C.I. without any previous instructions or prearranged plan."

> "The first few hours ashore were spent digging and diving in foxholes in an attempt to preserve life and limb from enemy artillery shelling, dive bombing and strafing. Around 1600 hours we noticed a hospital ward tent marked with the Red Cross being pitched approximately 300 yards inland from Red Beach. This was the place for us, since the Red Cross might offer us some feeling of security. On arrival we found this to be the 602nd Clearing Station, 162nd Medical Battalion, commanded by Captain Walter Lillehi. We immediately attached ourselves to this unit, proceeded to dig another foxhole, set up an operating tent and await the arrival of casualties. The first night and the following day were spent in setting up the hospital and operating section. Battle casualties during this period were evacuated directly to the ships standing off shore. During the afternoon of the second day ("D" plus one) the operating section preparations were complete. General Surgical Team No. 11 along with General Surgical Team Nos. 7 and 15 and Orthopedic Team No. 6 of the 2nd Auxiliary Surgical Group started doing what is believed to be the first operative surgery to be performed by American Surgeons of the United States Army, on the continent of Europe in World War II. Two of the four teams and much of the time all teams operated continuously for five days and nights. During this time our teams of the 2nd Auxiliary Surgical Group had complete charge of the operating section which included not only the surgery, but the triage, pre and postoperative treatment, sterilizing of all supplies, repairing the gasoline burners for sterilizers and autoclaves, the laundry, and much of the time the litter bearing.

The 95th Evacuation Hospital landed on "D" day. Two surgical teams of this detachment functioned with this hospital which was in operation by "D" day plus three.

The following extract from the report of Major Luther H. Wolff, MC, surgeon in charge of one of the surgical teams lists the diagnosis of the cases treated by his team during the first 96 hours after the initial landing at Paestum, Italy.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

"10 September 1943 -

(1) Thoraco-abdominal wound, involving chest, lung, diaphragm, spleen, jejunum, and colon. Shock profound. Strictly non-transportable.

(2) Strangulated hernia, inguinal. Twenty-four hour duration.

11 September 1943 -

(1) Wound, severe, involving buttocks, rectum and recto-sigmoid. Non-transportable.

12 September 1943 -

(1) Wound, severe, right flank. (a) Wound,moderate, right buttocks. (b) Wounds, minor, right forearm and arm.

(2) Wound, moderate, penetrating right buttocks and thigh.

(3) Wound, moderate, penetrating, intrathoracic.

(4) Wound, moderate, penetrating, left thigh.

(5) Wound, perforation, right arm. (a) Wound, penetrating, right cheek. (b) Wound, penetrating, right chest wall".

On "D" day plus six, the detachment of seven teams which had functioned in Sicily including nurses, landed at Paestum with the 93rd Evacuation Hospital. The nurses from this group and the 93rd Evacuation Hospital were among the first American nurses to arrive in Italy. Two surgeons from the Group were attached to the 94th Evacuation Hospital which also landed on the above date.

On "D" day plus 12, 21 September 1943, the second detachment of nine teams that had departed from Bizerte landed at Paestum, Italy.

The nurse members of the teams which were now functioning in Italy joined their respective teams during the period 15 to 21 September 1943. Nine nurses were aboard the British Hospital Ship "Newfoundland" off the shore of Salerno, Italy, on "D" day plus four awaiting to disembark and join their teams when the ship was bombed by the enemy and the vessel had to be abandoned. No American nurses were killed but five British nurses were lost. The nine nurses returned to Group Headquarters, Bizerte and again set sail for Italy and joined their respective teams 21 September 1943.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

On 1 October 1943 the disposition of the Group was as follows: Twenty-three surgical and shock teams were functioning with Fifth Army in Italy. The remainder of the Group was in the vicinity of Bizerte, Tunisia. On 1 October 1943 the surgical teams with the Fifth Army were employed in the following installations south of the Volturno River: 8th and 14th British Casualty Clearing Stations; 15th, 16th, 94th, 95th Evacuation Hospitals, also the 120th Medical Battalion and the 3rd Medical Battalion Clearing Station.

The crossing of the river had been accomplished and by 31 October the Army hospitals had moved north of the Volturno. The 33rd Field Hospital was now functioning as a first priority surgical hospital and 14 general surgical teams and shock teams began functioning in this installation. The Group Headquarters and the remainder of the teams arrived in Italy from North Africa 22 November 1943. Several teams which had been functioning since the early landings were relieved and replaced by recently arrived teams. The presence of the Group Headquarters was a boon to all. The entire unit was now together and functioning with a field Army on a mission for which it was originally designed. The control of all teams was taken over then by the Group Headquarters which relieved the Army Surgeon of that responsibility. All administrative matters, the movement of the teams, changes in the composition of the teams, housing and messing facilities for the Group became functions of the Group Headquarters. Likewise, needed vehicles were now available. The distribution of mail and the pay of all personnel was by the Headquarters. Reports of the experiences of the teams were obtained and based upon the information contained in these reports recommendations were made which later became accepted as general policy for the use and control of an Auxiliary Surgical Group functioning with a field Army. Also certain surgical practices in forward hospitals were altered to conform with the experiences and recommendations of the surgeons on these teams.

From 17 November to 15 January 1944, three phases of the winter line campaign occurred. Beginning on 17 November the first phase had secured the southern shoulders of the gap in the main enemy defenses in the Liri Valley. The southern shoulder of the gap was formed by the Mount Camino hill mass and the northern shoulders by the Mount Summacro hill mass and the mountains north and northeast of Cassino. In between lay the Mignano Gap. By 16 December 1944, the second phase had been partially completed with the caputre of Mount Summacro on the northern shoulder. Phase three of the winter line campaign focused attention on the mass of mountain barriers which stood in the way of an assault on the town of Cassino and the Gustav Line which hinged on Cassino. The extreme difficulty encountered in an offensive against this terrain and the strength of the enemy defenses is indicated by the fact that during the entire winter line campaign the total area penetrated was a nine mile wide belt of mountains. Thus, it is evident that there was little need for movement of Army hospitals. Throughout this period and until the

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

great May offensive was launched, the severe winter of cold, mud, rain and constant seemingly hopeless effort to advance characterized the hectic days along this front in Italy during the winter of 1943-1944. Only one first class road was available, Highway No. 6 and most of the hospitals were situated along this road during the winter line campaign.

Throughout the above period all the surgical and allied teams of this group functioned in Army installations. These included the 11th and 33rd Field Hospitals and occasionally the 10th Field Hospital, as well as the 16th, 38th, 94th, and 95th Evacuation Hospitals. One thoracic surgical team was employed in the 52nd Station Hospital and one thoracic surgeon in the 300th General Hospital in Naples.

(2) Rome-Arno Campaign (21 January 1944 - 15 August 1944).

(a) Stalemate at Cassino.

During this period all surgical and allied teams not employed at the Anzio-Nettuno Beachhead functioned at the Cassino Front in the 10th and 11th Field Hospitals and at various times in the 38th, 56th, 94th, and 95th Evacuation Hospitals. There were also specialty teams employed from time to time in Base Hospitals designated as surgical centers for the care of thoracic cases.

(b) The Anzio-Nettuno Beachhead (23 January 1944 - 4 June 1944).

The Group Headquarters, located in Marcianise, proved to be in an ideal location in view of the bilateral operational activity of the Fifth Army. The prolonged duration of the Anzio operation plus the stalemate at Cassino and the adverse conditions under which these military operations were carried out resulted in the most hazardous and difficult winter which this organization experienced. Two officers and one enlisted man were killed in action and 19 Purple Hearts were awarded to members of this Group functioning in the Anzio Beachhead operation.

> "The medical plan for the Anzio Operation derived its character from the nature of the overall tactical plan. The beachhead itself was designed to serve either as a magnet or as a dagger pointed at the rear of the German force in the Liri Valley. As a magnet, it could draw strength away from the Gustav Line and contribute to the success of an assault on that line by the main body of the Fifth Army. As a dagger, it could force the Germans to retire from the whole of the Liri Valley in order to husband the limited forces believed to be available to the German command-forces which would face the danger of being cut in two if they clung to their Liri Valley positions". (From Fifth Army Medical History, 1944).

These plans did not, however, result in a quick junction of the Fifth

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

Army forces and a long bitter struggle ensued during the winter. Four months were to elapse on the main Fifth Army front as well as the Anzio Beachhead before the limited successes of phase three of the winter line campaign could be exploited to their full potentialities.

Ten surgical and two shock teams were alerted about 10 January 1944 for movement with the 33rd Field Hospital which was to be under the control of VI Corps for the forthcoming operation. Four days before the initial landing was scheduled two of these surgical teams were attached to the 1st Ranger Battalion to support this latter organization in its early landings. No hospital facilities were to accompany these teams but the plans were for the two teams to rejoin the 33rd Field Hospital as soon as it was in operation. The feasibility of utilizing surgical teams in this manner is doubtful, and to partially overcome the known defects additional quantities of sterile surgical supplies and operating room equipment was included for these two teams.

On "D" day, 22 January 1944 and "D" day plus one, ten surgical and two shock teams, less nurse members of the teams, landed on the Anzio-Nettuno Beachhead and began functioning in the 33rd Field Hospital and 95th Evacuation Hospital. The two teams accompanying the Rangers were the first surgical teams to land and function on the Anzio Beachhead. On "D" day plus six the nurses joined their respective teams on the beachhead. On 10 February, 2nd Lt La Verne Farquhar, ANC, of this organization was killed by enemy action when the enemy shelled the 33rd Field Hospital.

On 21 January 1944, four surgical teams were placed on T/D with four British Hospital Ship carriers to evacuate and treat casualties encountered during the early hours and days of the beachhead landings. On the night of 24 January these ships were bombed by enemy planes. One of the three ships was sunk resulting in the death of one officer and one enlisted man of this organization. The following account was given by one of the nurses of this organization who survived this deliberate action by the enemy:

> "I was on board the British Hospital Carrier "St. David". It arrived off the coast of Port Anzio, Italy, about 1000 hours on 23 January 1944, approximately ½ mile off shore. Patients started arriving at about 1100 via motor boats which had been launched from our ship and L.C.I.'s coming alongside. Our team, consisting of Major John E. Adams, MC., Lt Hindman, ANC, Cpl. McCombs and myself began operating and by 0430, 24 January 1944 there were 78 patients on board who had received necessary surgery. We had moved out of the harbor for the night and came back that morning arriving at approximately the same distance from shore around the same time (1000). No patients were taken aboard that day as it was too rough to send our own boats out and none were brought aboard per L.C.I.'s. Shortly after lunch the air raids began and continued throughout the entire after-

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

noon. I was on deck most of the time and war ships were firing on all sides of us. At about 1730, we started out to sea for the night. We were told that there was a convoy coming in that was being raided, but we passed quite near it with our lights out, without being harmed. After we were four miles out the ships' lights were turned on. At about 1900, I went to my cabin and found Miss Hindman there asleep. At 2000 we were about 20 miles off shore with all the ships' lights on. I was suddenly awakened by a terrific explosion. Almost simultaneously all lights went out. Miss Hindman and I grabbed our life belts and ran to the upper deck where we saw Major Adams supervising the evacuation of patients. We said that we were going up to the next deck where the life boats were. As I started up the stairway I saw Major Adams going to the back of the ward to get some more of his patients who were still there. If he had come with us then he would have had time to get into the life boat because we immediately jumped into a life boat which simebody started lowering. After it was lowered about a foot it started turning over. I heard someone say 'The ship is sinking, jump'. I jumped into the water calling to Miss Hindman to follow me, but I couldn't see her. When I came up I could just see the last end of the ship going down. I tried to swim away from the ship so that I would not be pulled down by the suction. In a few minutes someone near called, 'Here's a raft', and I reached out and caught it. Gradually more people started hanging on until there were about 12 of us including one patient who was pulled onto the raft. We had two flashlights among us and took turns waving them as our arms became tired. We were hoping that someone in one of our lifeboats would see the light. After being in the water for about an hour we saw the lights of the British Hospital Carrier "Leinster" and the "St. Andrew". We kept waving the lights and calling until a life boat from the British Hospital Carrier "Leinster" came to us. The boat stayed out for sometime after we got aboard picking up other survivors. When we arrived at the ship, we were told to climb aboard the rope ladder as the sea was too rough to bring the boat up. Everyone climbed up except the patients, who were pulled up in the boat in spite of the difficulties. I was taken to the resuscitation ward".

Throughout the hazardous days of the Anzio Beachhead operations the enemy almost daily shelled and bombed the area occupied by the hospitals supporting the ground troops. Beginning in early April the teams functioning on the beachhead were rotated with those working on the Cassino front and practically all members of the group served at Anzio during the period of that battle.

The experience of this organization in amphibious operations warrants special comments and the following excerpts of a report from Major Charles F. Chunn, operating surgeon on a surgical team which participated in the entire Anzio operation, indicates the marked improvement in the facilities furnished surgical teams of this Group for the care of

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

their patients especially when compared with the early reports of the activities of teams in the Tunisian Campaign.

"On 20 January 1944 we boarded an L.S.T. and on the following day moved out of the harbor to join a large convoy. At about 0400 hours on 22 January 1944 we had reached our destination off Anzio-Nettuno, Italy. At 0830 hours our group was given orders to land on Red Beach. As we were climbing into the small landing craft a mine sweeper just next to us was seen to blow up. Evidently it had struck a mine and sank in about five minutes. We pushed off in our landing craft to pick up survivors but other small boats reached the scene before we did and did the job. Our craft was then turned toward Red Beach. At this time German air raids over the beach were occurring at frequent intervals. From the time we left the landing craft, waded ashore and crossed the beach we were bombed once with two near misses and strafed three times. As a result of these raids I received my first patients, casualties from an L.C.I. lying next to our craft, that had taken a direct bomb hit. Several soldiers and sailors were killed, one died a few minutes after I saw him. A soldier with a severe head wound and one with an abdominal wound were dressed by a naval medical officer. Our hospital platoon had not yet landed so these patients were evacuated to an L.S.T. At this time our medical equipment consisted of bandages and a small box of morphine."

"The L.S.T. carrying the Field Hospital equipment and supplies had been damaged during an air raid and was unable to unload until late afternoon. By dark the hospital platoon was set up enough to receive patients in the shock tent. This tent was filled almost immediately with wounded. We started operating and continued at the operating table for the next 24 hours. On 23 January more surgical teams were landed and our three teams were relieved for rest but not for sleep. Sleep was impossible due to the frequent air raids on the beach and the heavy artillery 1000 yards from us. The hospital platoon had been set up 1000 yards from the water."

"During the first days on the beachhead, supplies were limited and our equipment was pressed to the utmost. The water point had been hit by artillery fire and there was barely enough water for the operating tent and to drink. Surgical drapes, towels and gowns were soon exhausted. Food consisted of cold "C" rations and water. However, one of our most valuable items was present in adequate quantity due to the foresight of the captain of our shock team (Captain Lalich). The shock team brough with them 50 pints of blood (British). Most of this was used within the first 36 hours but that was time enough for more to arrive from the British blood bank".

"On 29 January an interesting and very pathetic thing occurred. A young Italian father carried his little three year old daughter into the hospital. The father was in tears and the little girl was very sick. She had been shot 24 hours before, through the left thigh and

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

> buttock, right, perforating the rectum. The father told the story that his daughter had been shot by Germans and that his wife had been carried away by the Germans. I did a sigmoid colostomy and resected the coccyx for drainage. The wounds were debrided. Alberta made an uneventful recovery and was evacuated to Naples 1 March 1944."
>
> "On 31 January the hospital platoon moved about a mile inland and continued receiving patients. We were set up in a field next to the 56th, 93rd and 95th Evacuation Hospitals. On the afternnon of 7 February 1944, the 95th Evacuation Hospital was bombed by a German plane causing approximately 30 deaths and 80 wounded of the hospital personnel and patients. The 33rd Field Hospital which was adjacent to the 95th Evacuation Hospital received the severely wounded."
>
> "A move of four miles toward the front was made by the platoon on 16 February 1944. We operated at the location until 29 February at which time the hospital area was heavily shelled by German artillery. An emergency evacuation of patients was carried out and the platoon evacuated the following day. We set up the hospital in the area we had left two weeks previously".

All hospital installations functioning on the Anzio Beachhead required surgical teams to care for battle casualties. These installations included: 33rd Field Hospital, 11th, 15th, 38th, 56th, 93rd, 94th and 95th Evacuation Hospitals. In this battle all hospitals were grouped in one area and the usual policy of delegating the first priority surgical cases to field hospitals was not feasible. All hospitals shared in the care of all types of battle injuries. One surgical team of the group which accompanied the Rangers was detailed to function with the 2nd British Casualty Station set up about three miles from Anzio. Throughout the following four and one-half months this team had a most interesting and profitable tour with the British.

A total of 10809 battle casualties were treated in the medical installations on the beachhead. A fair share of these casualties received their treatment from members of the 2nd Auxiliary Surgical Group. No other military operation in which this unit has participated will be remembered longer than the hectic days spent on the Anzio Beachhead.

(c) The Advance on Rome (11 May 1944 - 4 June 1944).

On 11 May the great offensive on Rome was launched and the breakthrough from the Anzio Beachhead with the junction of the forces from the main Fifth Army effected on 25 May 1944. In preparation for this major offensive the U. S. forces which comprised the II Corps moved to a sector of the front which had been occupied by the British X Corps. This new sector for U. S. troops was a narrow strip of territory running 13 miles inland from the sea to the Mount Camino hill mass. The French Expeditionary Corps was placed on the right of

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

the II Corps. In conformity with this shift of combat forces medical installations were shifted to the new sectore being located along the only main road, Highway No. 7.

The advance on Rome was characterized by rapid movements of surgical teams in all Field and Evacuation Hospitals. The organic team transportation greatly facilitated the team movements. These movements were accomplished by pooling the transportation and dispatching it from Group Headquarters plus alloting a minimum number of vehicles to each group of teams employed in hospitals several miles from the Group Headquarters. Group Headquarters moved from Marcianise to Carano, Italy 28 May and on to Anzio on 4 June 1944. Headquarters was established in Rome, 11 June 1944, six days after the city fell to Allied troops.

Following the junction of the forces on the Cassino front with those at Anzio it became a common experience for surgical teams to report to a platoon of a Field Hospital and find that the site selected for the hospital 24 hours earlier was now many miles behind the front. During this phase of rapid advance there were fortunately few casualties, and frequent and long moves of the hospitals, particularly the first priority surgical hospital, were necessary to give adequate support to the combat forces.

Throughout the advance on Rome, surgical and shock teams from the Group were employed continuously in the 10th, 11th, and 33rd Field Hospitals and in the 8th, 15th, 38th, 56th, 93rd, 94th, and 95th Evacuation Hospitals.

(d) Pursuit North of Rome (5 June 1944 - 8 September 1944)

The battle of pursuit North of Rome covered a distance of 150 miles and continued a period of about six weeks. Highway No. 1 was the principal axis of advance for the U. S. troops. It is the coastal road and runs northward to Civitavecchia, Grosseto, Piombino, Cecina, Leghorn and Pisa. During this battle of pursuit the elements of this Group moved rapidly. During the 19 day period in which the Group Headquarters was situated in Rome there was sufficient lull in the activity at the front to permit many teams to be reassembled at the Group Headquarters. This offered an excellent opportunity for sight seeing trips in Rome and a much needed rest. Team equipment was carefully checked and needed articles furnished. Vehicles were repaired. Several changes in team assignment were made and preparation made to move northward. The respite was short and durng this period surgical teams functioned constantly in the first priority surgical hospitals although the number required was less than during the periods of heavy fighting.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

The disposition of the elements of the Group as of 30 June 1944 was as follows:

Four general surgical teams.
One shock team...................... 11th Field Hospital.

Four general surgical teams.
One thoracic team.
One shock team...................... 33rd Field Hospital.

Two general surgical teams......... 15th Evacuation Hospital.

Two neurosurgical teams.
Two orthopedic teams............... 94th Evacuation Hospital.

One dental prosthetic team......... 3rd Infantry Division Headquarters.

One dental prosthetic team......... 16th Evacuation Hospital.

One maxillo-facial team............ 52nd Station Hospital.

One neurosurgical team.
One maxillo-facial team............ 38th Evacuation Hospital.

One neurosurgical team............. 56th Evacuation Hospital.

One thoracic surgeon............... 300th General Hospital.

Eighteen general surgical teams.
One dental prosthetic team.
Three shock teams.
Three thoracic teams.
Two orthopedic teams............... Group Headquarters.

On 1 July 1944 Group Headquarters was established in tentage in the vicinity of Follonica, Italy on Route No. 1. Several teams were recalled from the Evacuation and Field Hospitals. Early in July preparations were made for twenty-eight surgical, shock, and dental prosthetic teams to be attached to the Seventh Army for forthcoming operations.

The plan for the employment of surgical teams of this Group with the Seventh Army had been originally formulated in early February 1944. Six months were to elapse, however, before the campaign in Italy had advanced far enough to permit the release of the combat and service troops required to comprise the Seventh Army for the invasion of Southern France. All forces initially engaged in this operation were taken from

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

Italy and the operation was carried out by NATOUSA. In addition to the U. S. troops involved in this operation, the French Expeditionary Corps was released from the Fifth Army and made a part of the Seventh Army. All of the teams of the Group except one neurosurgical and two dental prosthetic teams were to land on "D" day with the 10th and 11th Field Hospitals, two platoons each of these hospitals supporting the 3rd, 36th, and 45th Infantry Divisions. The latter teams accompanied the Evacuation Hospitals. The importance of loading all equipment of the first priority hospital and that of the surgical teams to be employed in the hospital on the same ship with the personnel (combat loading) was demonstrated in this operation. The personnel and equipment arrived on the beach together and the hospital was able to function on the day of landing.

The employment of this large number of surgical teams at such a great distance from Group Headquarters again presented the problem of having a headquarters with any appreciable number of teams regardless of where they were employed. In the original plan of February 1944, it was recommended that the Group Headquarters be divided for this operation. Under that plan all of the teams would function in one theater, NATOUSA, and the main headquarters would be designated wherever the main body of the Group was employed. A detachment of the Headquarters would be designated and employed in the location of the smaller number of teams of the Group. The original operation did not materialize as scheduled for April 1944. When the plan for the August operation became known to this organization it was surprised to find that the plan called for an administrative headquarters detachment of three individuals to follow the landing of the teams on about "D" day plus 30. On the request of the Commanding Officer of the Group, this was altered to include approximately one half of the Headquarters to function as a detachment Headquarters. The main Headquarters remained in Italy. The executive officer and adjutant accompanied the detachment of Group Headquarters, composed of these two officers and 26 enlisted men, which arrived on "D" day plus 16. This Headquarters detachment assumed control of the teams functioning with the Seventh Army. The Commanding Officer of the Group arrived in France ahead of this detachment and during the following eight months divided his time in supervising the activities of both portions of the organization functioning in France and Italy.

Throughout the experience of this Auxiliary Surgical Group in an active Theater of Operations it has been constantly evident that one Auxiliary Surgical Group is needed for each actively engaged type field Army. This was the experience in the Fifth Army prior to the fall of Rome when seven American divisions composed a part of the Army, and again true in our experience with the Seventh Army in France. To emphasize this fundamental concept in the employment of an Auxiliary Surgical Group in the operational activities of a field Army, the following is quoted from the Fifth Army Medical Service History, 1944:

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont d).

"Without doing violence to the sequence of events, the condition which came to face Fifth Army in subsequent months was succinctly expressed in a letter of 15 December 1944, written by the Commanding General of Fifth Army to the Commanding General of MTOUSA. The letter reads, in part: 'Based upon the assumption that Fifth Army would consist only of one U. S. Corps (with not more than three divisions actively engaged) with a very narrow front, an unusually large number of Fifth Army service units were assigned to Seventh Army to support adequately French and U. S. operations. Since 15 July 1944, the 92nd Infantry Division, a Brazilian Infantry Division... the... Infantry Regiment and the .... Tank Battalion have been added to the Fifth Army troop list without addition of any service units other than those being activated... Not only has ther been an increase of combat troops, but Fifth Army has been required to commit two Corps on a wide front.. with the result that a critical shortage of service units has developed and is severely handicapping the Fifth Army operations at one of the most critical times of the Italian Campaign. Fifth Army now has seven Evacuation Hospitals to support six U. S. divisions, one Brazilian division and one separate Infantry regiment... One complete surgical group is necessary to provide adequate surgery for Fifth Army.... Fifth Army has operated several months with an insufficient number of surgical teams and it has been necessary to provide teams from Evacuation Hospitals for Field Hospitals in forward areas and this has seriously reduced the surgical service of the Evacuation Hospitals... A few teams have been provided from base units at various times. If it was necessary to attach these teams during the time Fifth Army was regrouping, additional teams will be necessary when active operations begin... Duration of attachment of Base Section Hospital teams to Evacuation Hospitals has been limited and the teams are often recalled during the time when their need is critical. The solution most desirable to Fifth Army is the return to Fifth Army of that part of the Second Auxiliary Surgical Group which was assigned to Seventh Army..'."

The 28 teams comprising the detachment left the Group Headquarters near Follonica, Italy, 15 July 1944 enroute to Naples. They landed, less the nurses, on "D" day (15 August 1944) near St. Tropez, in Southern France. The headquarters detachment arrived in France 4 September 1944.

(3) Southern France Campaign (15 August 1944 - 14 September 1944).

The teams were divided into four detachments and assigned to different assault transports. These ships anchored off the coast of Southern France near St. Tropez on the morning of 15 August 1944 in time to witness the naval and plane bombardment that preceded the invasion. "H" hour was 0800 and the teams began to land at Red, Green, and Yellow Beaches from about noon on "D" day until the afternoon of "D" day plus one. They proceeded to their assignments in various hospitals and medical battalions. Two teams were working

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

the night of "D" day. The rest of the teams began work on the following day and continued to work and move along with the troops as they pushed up the Rhone Valley. One team was attached to the Rangers whose mission it was to take L'Isles de Hyeres. This team remained on their ship, the "Prince Henry", just off shore and treated the casualties as they were brought back to the ship. When this mission was accomplished they were landed on Southern France and joined the 11th Field Hospital.

After the landings, the 10th and 11th Field Hospitals, to which most of the teams were attached, supported the 3rd, 45th and 36th Infantry Divisions. Due to the rapid advance of the Seventh Army up the Rhone Vally and the small number of casualties the teams spent much of their time in moving. The main axis of movement was through Draguignan, Grenoble and Lons le Saunier. Detachment Headquarters landed in France on 4 September and bivouacked near St. Raphael. The next few days were spent in locating the teams that had preceded the Detachment Headquarters into France. The majority of teams were found to be located in the vicinity of Lons le Saunier, France, so on 10 September, the detachment Headquarters departed from St. Raphael and arrived at Lons le Saunier, France, on 11 September traveling a distance of 333 miles. Detachment Headquarters was set up in one wing of the Seminary Montciel in the south end of the city. On the 14th of September the Detachment Headquarters assumed control of the surgical teams of this group then in France. Two general surgical teams were on duty with the 9th Evacuation Hospital at Poligny; a neurosurgical and a dental prosthetic team were with the 95th Evacuation Hospital at St. Amour; one neurosurgical team was with a Prisoner of War Hospital at Aix-en-Provence; one dental prosthetic team was with the 11th Evacuation Hospital near Besancon; six general surgical, one thoracic, two orthopedic, one maxillo-facial and two shock teams were on duty with the platoons of the 10th Field Hospital which was supporting the 3rd Infantry Division; and six general surgical, one thoracic, one orthopedic and two shock teams were with the 11th Field Hospital supporting the 36th and 45th Infantry Divisions. This comparatively short campaign characterized by a very rapid advance taxed all efforts to keep the surgical teams and first priority surgical hospitals close to the fighting front.

(4) North Appennines Campaign (10 September 1944 to 4 April 1945).

Reverting to the sequence of events on the Fifth Army front the months of July and August witnessed very little activity but a regrouping of the elements of the Fifth Army (U.S.) and Eithth Army (Br.) occurred. The former forces moved eastward from the coastal area and in the general areas south of Florence. The difficult mountainous terrain again faced the Fifth Army. The position of the front which was to witness the area of the Fifth Army operations for the fall and winter months of 1944-1945 contained the most formidable peaks in the German Gothic Line. The density of these peaks on the Fifth Army's left flank promised little strategic gain for any concentrated effort in this region.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

The area north of Florence, however, while still forbidding was more promising. The medical installations were moved to positions in the vicinity of Florence. The Group Headquarters had moved from the vicinity of Follonica to Cecina 23 July 1944 and remained there until 5 September when it moved to Poggibonsi. On 12 August, Florence, Italy fell and the Group Headquarters moved 21 September to the vicinity of Pratolino. With the fighting in the Gothic line mounting in fury in September and reaching the most concentrated form in October and early November, the operational activities of this Group became great. During the bitter fighting for the Gothic line in the winter months, the highest sustained casualty load in the history of the Fifth Army occurred. In October 1944 the distribution of the teams of the portion of the Group functioning in Italy is portrayed in Figure 100.

(a) Battle of Approaches to Po Valley (9 September 1944 - 31 December 1944).

In the immediate period leading up to and after the breakthrough of the Gothic Line the surgical and shock teams of this Auxiliary Surgical Group were for the most part employed in the various platoons of the 32nd and 33rd Field Hospitals.

During the summer months several surgical and shock teams from Base Hospital installations were placed on temporary duty with this organization for employment in Army Hospitals. In general, the teams from the Base Hospitals were placed in Evacuation Hospitals where their work could be easily supervised, and the casualties treated were not as severe as those cared for by the surgical teams in first priority surgical hospitals. Surgical teams from the regular staff of the Evacuation Hospitals were selected to augment the surgical teams from this organization for employment in these priority hospitals. This arrangement worked satisfactorily. However, in fairness to all it must be stated that the nature of the surgical treatment required in first priority surgical hospitals differs greatly from that required in other hospitals and experienced surgeons are the product of many months of employment in these installations. The Base Hospital teams worked diligently and the experience gained aided many of the members of these teams when they were subsequently employed in forward hospitals. The fierce fighting of October, November and the early part of December resulted in very limited progress and the stalemate before Bologna developed. Group Headquarters moved 4 November 1944 to and occupied the Institute of Hygiene, Florence until 27 April 1945.

(b) Stalemate Before Bologna.

The months of January, February and March were punctuated with very limited activity on the front. During this period an interesting experience for several of the members of the Group was encountered in working with Brazilian surgical teams. The exchange of

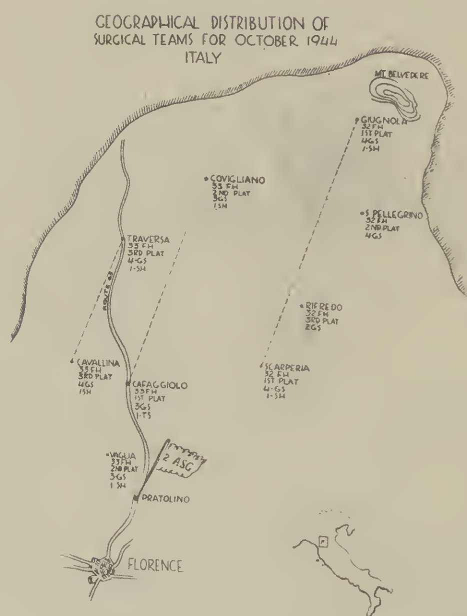


Figure 100. Geographical Distribution of Surgical Teams, October 1944, Italy.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

ideas and surgical methods proved profitable to the members of teams from both nations. All of the teams available from this Group were almost constantly functioning in the two Field Hospitals. Opportunity did, however, present itself for occasional rest periods and rotation of teams from Headquarters to the Field Hospitals.

(5) Rhineland Campaign (15 September 1944 - 21 March 1945).

The Rhineland campaign in which elements of this organization participated was a long and often bitterly fought series of battles characterized by slow progress, mountain fighting, stalemates, a stratigic withdrawal, and the inclement weather of Alsace. During the first month of the campaign the advance was rapid and the surgical teams moved many times. To keep apace with the fighting front the detachment Headquarters moved fron Lons le Saunier to Vesoul 22 September. The stay here was short and on 2 October Headquarters moved to the town of Epinal situated along the Moselle River. This was in close proximity to the Headquarters VI Corps, Seventh Army, and the hospitals in which the teams were employed. The detachment Headquarters remained in Epinal until 8 December 1944. The disposition of the teams of the detachment as of 1 October 1944 was as follows:

Seven general surgical teams.
One orthopedic team.
One thoracic surgical team.
One shock team.................. Remiremont
10th Field Hospital
Units I and III.

Three general surgical teams.
One thoracic surgical team.
One shock team.
One orthopedic team............. Eloyes
11th Field Hospital
Unit III.

Four general surgical teams.
One thoracic surgical team.
One shock team.................. Epinal
11th Field Hospital
Unit II

Three general surgical teams.
One shock team.................. Luneville
54th Field Hospital
Units I and II.

One general surgical team.
One orthopedic team............. Moyen
54th Field Hospital

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

One orthopedic team
One dental prosthetic team........ Plombieres
9th Evacuation Hospital.
2nd Convalescent Hospital.

One maxillo-facial team
One neurosurgical team............ Besancon
46th General Hospital.

One dental prosthetic team........ Bourbonne (les Bain)
3rd Division Rest Center.

On 1 November the detachment was transferred from the control of NATOUSA to ETOUSA. During this month two important factors influenced the operational activities of this detachment. First, several newly arrived hospitals began their first overseas experience by functioning with the Seventh Army. Second, a detachment consisting of surgical and allied teams of the 1st Auxiliary Surgical Group was placed under operational control of the detachment Headquarters of the 2nd Auxiliary Surgical Group. This latter development was a new experience for the Group. Throughout the six months in which elements of the 1st Auxiliary Surgical Group functioned under the control of this organization the same policies governed the use and control of both Auxiliary Surgical Groups. The teams from the 1st Auxiliary Surgical Group were made available to the Seventh Army in anticipation of the Allied assault on the Vosges Mountain Line. The operational plan considered best fitted for the employment of these latter teams was to have teams from both Auxiliary Surgical Groups function together in each of the engaged first priority surgical hospitals. This plan placed experienced teams from our own Group in a position to aid and assist the less experienced teams from the 1st Auxiliary Surgical Group. This enabled the latter teams to rapidly familiarize themselves with the specialized problems of the surgical care of non-transportable casualties. This plan proved highly successful.

The recently arrived hospitals included two Field Hospitals, 54th and 57th, and two Evacuation Hospitals viz., 116th and 117th. The platoons of Field Hospitals were employed as first priority surgical hospitals and the surgical teams of the Group assumed the responsibility for the surgical care of the patients treated in these hospitals. The Field Hospitals were clearly informed of this function prior to actual operation and the detailed changes required in their organizational set-up, to permit them to function in this way were readily effected. The 54th Field Hospital was employed in support of a division of the XV Corps. On 19 November the 57th Field Hospital began functioning in support of the left flank of this Corps. Individual surgeons and teams of the Group were also employed in the newly arrived Evacuation Hospitals. Their principal function was to assist the surgical staff of the hospital in developing its plan for the care of casualties. This involved the performance of a portion of the surgery and instructing members of the

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

surgical staff of the hospital in the methods of surgical management outlined by the policies of the Theater and the Seventh Army. The plan proved beneficial to all concerned. As November ended moderate progress had been made along the front and the detachment Headquarters moved early in December to Lixheim, France.

The tactical situation in the month of December hinged about the fact that the long corridor extending into Strasbourg had been widened and the axis of advance shifted to the north to take over some of the Third Army sector. The German breakthrough in the Ardennes required that certain elements of the Third Army be taken by the First Army and the Seventh Army front was further extended into the area previously held by the Third Army. A defense position was assumed in the Seventh Army area and by the end of the month the Colmar "pocket" was the area from which most of the casualties were received. As December came to a close the 10th, 54th and 57th Field Hospitals went into bivouac and the surgical teams functioning with them were relieved and returned to detachment Headquarters. This afforded a welcomed respite for many of the teams' members who had been functioning constantly in first priority surgical hospitals since the initial landings in Southern France.

During the remainder of the Rhineland Campaign the activity of the front was limited. The Seventh Army was employed principally in defensive action and except for the period of heavy fighting in the Colmar "pocket" the casualties were light. In the last part of December and first part of January a strategic withdrawal was effected as a result of the German Ardennes breakthrough. In the month of February the casualties were heaviest in the 70th Infantry Division area as this division was meeting moderate resistence in its attempt to straighten out their lines below Saarbrücken. Also, the 36th Infantry Division had a moderate number of casualties while contending with the bridgehead which the Germans had established on the west bank of the Rhine above Strasbourg. On 1 February 1945, the teams of this detachment were employed in the following installations: Fig. 101.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

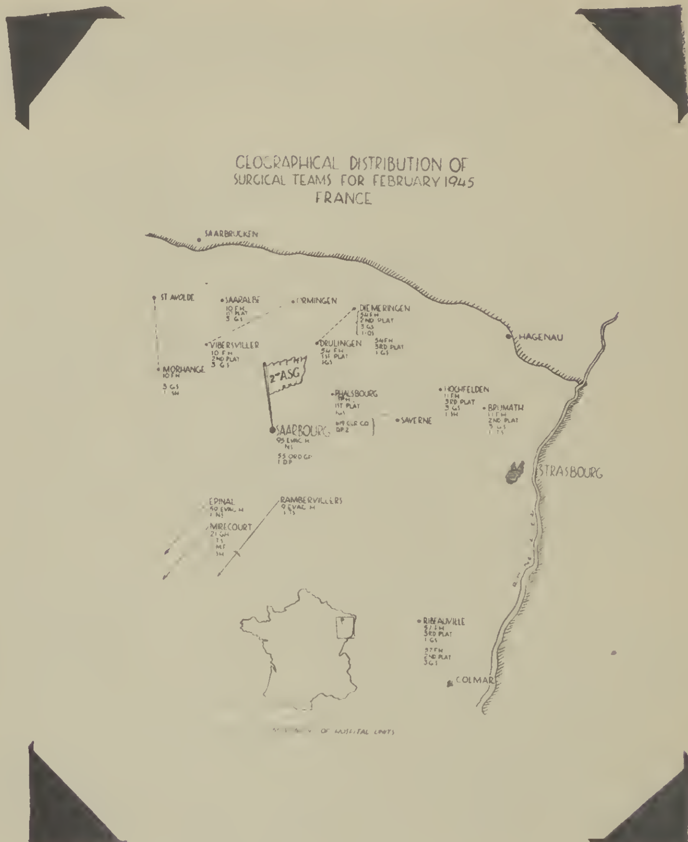


Figure 101. Geographical Distribution of Surgical Teams, February 1945, France.

By the middle of March preparations had been completed for the final offensive against the Seigfried Line and the advance into Germany.

(6) Po Valley Campaign. (14 April 1945 - 8 May 1945).

The campaign in Italy took on new vigor in a victorious spring offensive. Preparations for the offensive directed to driving the enemy from the mountains blocking the entrance to the Po Valley were inaugurated. Surgical and shock teams from base Hospitals were again required to augment the Army Hospitals. A total of 22 surgical and two shock teams from the Base installations were attached to this unit to

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

control their employment in the Po Valley campaign. Likewise, all surgical teams from Evacuation Hospitals employed in Field Hospitals during the campaign and the latter part of the North Appennines campaign were placed under the operational control of this headquarters.

A Surgeon from this Group was selected in consultation with the Army consultant surgeon and designated as chief of the surgical service in each of the first priority surgical hospitals. This officer was charged with the coordination of the activities of all the teams functioning in that particular hospital. He took a very active part in directing the management of shock and designating the priority for surgery among the casualties admitted. During this period surgical teams from Base Hospitals as well as from Evacuation Hospitals functioned in priority surgical hospitals and the designation of a surgeon experienced in the surgical management of first priority surgical casualties proved to be very desirable.

The disposition of the organic and attached elements of this Group functioning with the Fifth Army, in support of the 1st Armored, 91st, 92nd, 88th, 85th, and 34th American Infantry Divisions, the 10th Mountain Division and the Brazilian Expeditionary Force on 22 April 1945, eight days after the offensive started, was as follows:

Two general surgical teams. One shock team....................	32nd Field Hospital Unit A.
Five general surgical teams. One shock team. One surgeon, Chief of the Surgical Service................	32nd Field Hospital Unit B.
Three general surgical teams. One thoracic surgical team. One shock team....................	32nd Field Hospital Unit C.
Five general surgical teams.......	33rd Field Hospital Unit A.
Four general surgical teams. One shock team. One surgeon, Chief of the Surgical Service................	33rd Field Hospital Unit B.
Two general surgical teams. One shock team....................	33rd Field Hospital Unit C.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

One general surgical team. One shock team. One surgeon, Chief of the Surgical Service................	15th Field Hospital. Unit A.
One general surgical team. One orthopedic surgical team......	94th Evacuation Hospital.
One general surgical team. One orthopedic surgical team......	15th Evacuation Hospital.
Two general surgical teams........	16th Evacuation Hospital.
Two general surgical teams. One maxillo-facial surgical team..	38th Evacuation Hospital.
One neurosurgical team............	56th Evacuation Hospital.
One general surgical team.........	170th Evacuation Hospital.
One thoracic surgeon and surgical technician in charge of Thoracic Surgical Service..................	70th General Hospital located at Pistoia.
Dental Prosthetic Team No. 4......	Division Clearing Station, 10th Mountain Division.
Dental Prosthetic Team No. 3......	Fifth Army Enlisted Mens Rest Camp.
One oral surgeon and one dental technician......................	Dental Clinic, 602nd Clearing Company, 162nd Medical Battalion, (Sep).

During the first three or four days of this advance little progress was made against the German resistance. However, as the enemy positions were penetrated the advance gained in momentum. Bologna fell 21 April 1945. The battle of pursuit across the Po Valley was essentially a duplication of the pursuit north of Rome. The movement of the surgical teams was rapid and again the availability of organic transportation was invaluable in permitting the teams to keep pace with the rapidly advancing front. The first hospital across the Po river was a platoon of the 33rd Field Hospital. For a few days it was the only hospital across the river and treated many casualties which were transportable.

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

However, available means of transport across the Po River were too limited to permit any longer chain of evacuation than was absolutely necessary. The rapid advance became a rout and during the last week of April it was difficult to keep contact with the enemy. On 2 May 1945 the German Armies surrendered unconditionally to the Allies.

Group Headquarters moved from Florence, Italy to Modena on 27 April and was located in that town at the termination of hostilities. It moved to Garda, Italy on 20 May and to Riva, Italy 9 June 1945. On 14 June 1945, the detachment which had functioned with the Seventh Army in France and Germany rejoined the parent unit in Italy.

(7) Central Europe Campaign. (22 March 1945 - 11 May 1945).

The start of the campaign in Central Europe marked the beginning of a powerful offensive by the Seventh Army which was to carry it in a final victorious sweep across Southern Germany and Austria and end in the capitulation of German Army Group "B". As the offensive commenced the Seventh Army attacked the Seigfried Line and in conjunction with the Third Army proceeded to liquidate the entire Saar "pocket". These operations were carried on with such rapidity that it was found necessary to move the Detachment Headquarters to Kaiserslautern, Germany in order to maintain proper liaison with the teams which were then employed in hospital installations located over a large area. Casualties sustained by our forces during the attack on the Seigfried Line were heavy, and the surgical teams were intensively active. Toward the end of March the Rhine River was crossed. An unusually light number of casualties were incountered in this operation.

The teams released during February from the 57th Field Hospital were placed on temporary duty with the 64th and 66th Field Hospitals, two new arrivals overseas who had had but limited experience in the field during hostilities. These installations were employed mainly as holding hospitals supporting the 10th and 11th Field Hospitals during this period.

The month of April was characterized by days of dramatic pursuit of the disorganized, broken, German Armies. The pace was so rapid that the teams had to spend considerable time traveling to keep up with the advancing Army, leaving relatively little time in which to carry on their professional activities. The assaults on the cities of Aschaffenburg, Nurnberg, and Munich marked the only phases in which heavy casualties were encountered and the teams were busily engaged. In keeping with the swift advance, detachment Headquarters was moved from Kaiserslautern to Hardheim, Germany on 6 April, to Schwabisch Hall on 24 April and to Schwabisch Gmund on the 26th of April.

On 9 April a general surgical team of this group volunteered to fly to the aid of casualties of the 10th Armored Division which was surrounded by the enemy at Crailsheim, Germany. After performing

Operational Activities (Operational Activities During The Campaigns In Which This Organization Participated, cont'd).

three major surgical operations and treating all the other casualties during the period of the next 24 hours, this team was ordered to return with the combat teams along a path of exit that had been made for them. The report of Major Charles F. Chunn, surgeon in charge of this team vividly describes their experiences:

"The team reported to the Surgeon of VI Corps at Mosbach, Germany and was immediately taken to the airfield and put aboard L-5 planes and given instructions for parachuting if it became necessary. At about 1800 hours on 9 April, 1945, the team plus surgical instruments only, took off in six planes, heading for Crailsheim, Germany, to give surgical care to two combat teams of the 10th Armored Division which had been cut off by the enemy for two or three days.

After about 30 minutes plane trip the planes landed on the air strip at Crailsheim in heavy enemy mortar fire.

Major Chunn received a penetrating mortar fragment wound of the right hand. Several soldiers at the air strip were wounded and one transport plane was "knocked out" by the mortar fire.

Personnel and instruments were collected and the team was taken to the 80th Clearing Station of the 10th Armored Division which was in the basement of a building in Crailsheim.

About 35 wounded American soldiers were then at the station. In this group of wounded there were two patients with perforating wounds of the abdomen, four patients with perforating or penetrating wounds of the chest, two of whom had tension pneumo-hemothoraces of two days duration. The remaining wounded consisted of extremity wounds with the exception of one penetrating wound of the head.

The operating room was immediately set up and the two patients with tension pneumo-hemothorax were treated, relieving the tension, aspirating the chest and the giving of plasma. Whole blood was not present. However, three Baxter blood transfusion bottles were found in the clearing station and 1500 cc. of blood was drawn from soldier donors. Five hundred cc. of blood was given to one chest case, and 1000 cc. of blood given to one abdominal case who was in extreme shock. The remaining shock therapy was done with plasma. During the night two exploratory laparotomics were done, the two chest patients were treated. All other wounded were treated with penicillin, plasma if necessary, splints and dressings. No other surgery was attempted that night due to the absence of blood, sterile dressings, oxygen and adequate light. Surgical gowns and drapes were exhausted on the first operation.

During the night the town was under constant enemy shell fire and strafing. The building was hit at least once.

On 10 April 1945 at about 1400 hours, 40 bottles of whole blood arrived. Total patient admissions to this date were 53.

Operational Activities (Operational Activities During The Campaigns in Which This Organization Participated, cont'd).

At this time all patients were evacuated, including the postoperatives as there were no facilities for postoperative care. One abdominal and one chest case died postoperatively, the remaining were evacuated in good condition.

At 1700 hours, 10 April 1945, a soldier was brought in with a perforating wound of the abdomen. He was treated for shock and prepared for surgery. The patient was given other anesthesia and was being draped when an immediate evacuation order arrived. The patients wounds were dressed and when he reacted from anesthesia he was evacuated to a Field Hospital.

The clearing station and surgical team rapidly packed and at 1900 hours, evacuated Crailsheim in half-tracks of the last combat team to leave town. The column's front and rear were protected with tanks and the evacuation was carried out under cover of American artillery barrage in orderly fashion. As far as is known two half-tracks and one truck were lost.

The evacuation terminated at 0400 hours 11 April 1945, some 30 miles west of Crailsheim. During this entire interval general surgical team No. 18 was active in surgery, shock therapsy, postoperative treatment, the evacuation of patients and the evacuation of Crailsheim, Germany".

On 6 May the enemy forces surrendered to the Seventh Army. All the teams with the exception of two general surgical teams were gradually recalled to detachment Headquarters. The remaining two teams were employed at the 11th Field Hospital which acted as a Station Hospital for the troops in the Eberbach sector. On 14 June the detachment which had been functioning with the Seventh Army in ETOUSA, rejoined the parent unit in Italy and reverted to the control of MTOUSA.

SUMMARY

Upon the basis of over three years experience an efficient control of the operational activities of this Auxiliary Surgical Group has been progressively achieved. Its varied experience has permitted the formulation of flexible policies believed to be applicable to other such organizations functioning with a field Army. These policies have been detailed in this section. On 27 August 1945 the operational activities of the 2nd Auxiliary Surgical Group were substantially completed.

IV

ROSTER OF PERSONNEL

2ND AUXILIARY SURGICAL GROUP

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP

NAME	RANK	DUTY	DATES
ABAJIAN, JOHN JR.	Capt	Anesthetist	21 Dec 42 - 16 Feb 43
ABRIEL, ALBERT G.	Capt	Anesthetist	24 Feb 43 - 27 Aug 45
ADAMS, ARTHUR J.	Capt	Anesthetist	4 Oct 42 - 31 Mar 45
ADAMS, JOHN E.	Major	Orthopedic Surgeon	26 Sep 42 - 31 Jan 44
ADKINS, TROGLER F.	Capt	Asst Gen Surgeon	5 Oct 42 - 20 Nov 44
		General Surgeon	21 Nov 44 - 27 Aug 45
AHEARN, THOMAS F.	Capt	Asst Gen Surgeon	29 Apr 44 - 14 Aug 45
ALFTINE, DAVID C.	Capt	Asst Gen Surgeon	24 Sep 42 - 9 Apr 44
		OC Shock Team	10 Apr 44 - 23 Jun 44
AUSHERMAN, HOWARD	Capt	Anesthetist	14 Sep 42 - 1 Feb 43
BALLANTINE, HENRY T. JR.	Major	Neurosurgeon	7 Sep 42 - 13 Jun 43
		General Surgeon	14 Jun 43 - 27 Aug 45
BARNETT, THEODORE	Major	Asst Gen Surgeon	10 Oct 42 - 18 Feb 43
BARRETT, JOSEPH F.	Capt	Anesthetist	7 Mar 43 - 4 Jan 44
BEDELL, HAROLD	Capt	OC Shock Team	7 Mar 43 - 27 Aug 45
BEECH, ROBERT D.	Capt	OC Shock Team	7 Oct 44 - 27 May 45
BERLIN, ERWIN S.	Capt	OC Shock Team	14 Sep 42 - 1 Aug 43
		Asst Gen Surg	2 Aug 43 - 11 Jan 44
		OC Shock Team	12 Jan 44 - 31 Mar 44
BETTS, REEVE H.	Major	Thoracic Surgeon	22 Sep 42 - 27 Aug 45
BIRELY, MORRIS F.	Capt	OC Shock Team	7 Mar 43 - 6 Aug 43
BLOCKSOM, BERGET H. JR.	Major	General Surgeon	5 Oct 42 - 12 Jun 45
BOLTON, BERNARD	Capt	Asst Ortho Surgeon	28 Sep 42 - 1 Jan 43
BOS, HOWARD C.	Capt	Orthopedic Surgeon	28 Sep 42 - 26 Dec 42
		General Surgeon	27 Dec 42 - 27 Aug 45
BOWERS, FREDERICK W.	Major	Anesthetist	28 Sep 42 - 27 Aug 45
BOWYER, ARKIE B.	Capt	Anesthetist	23 Apr 45 - 27 Aug 45
BRADFORD, ARVILLE W.	Capt	Asst Gen Surgeon	28 Sep 42 - 8 Jun 43
BREWER, LYMAN A. III	Major	Thoracic Surgeon	17 Sep 42 - 27 Aug 45
BRINKER, HERBERT J.	Major	General Surgeon	28 Sep 42 - 5 Feb 45
BROTT, CLARENCE R.	Capt	Asst Gen Surgeon	7 Mar 43 - 28 Jun 43
		Asst Ortho Surgeon	29 Jun 43 - 8 May 44
		Asst Gen Surgeon	9 May 44 - 27 Aug 45
BROWN, FREEMAN F. JR.	Capt	Anesthetist	7 Mar 43 - 10 Aug 45
BROWNELL, PAUL G.	Capt	OC Shock Team	28 Sep 42 - 16 Feb 43
BURBANK, BENJAMIN	Major	OC Splint Team	24 Jun 42 - 18 Aug 42
		OC Misc Team	19 Aug 42 - 13 Jul 44
		OC Shock Team	14 Jul 44 - 10 Jun 45
BURFORD, THOMAS H.	Major	Thoracic Surgeon	14 Sep 42 - 20 Aug 45
BURICH, FRED T.	Capt	Asst Gen Surgeon	26 Aug 44 - 14 Aug 45
BYERS, WALTER L.	Capt	Asst Gen Surgeon	5 Oct 42 - 30 Nov 44
		Asst Neuro Surgeon	1 Dec 44 - 31 Mar 45
		General Surgeon	1 Apr 45 - 27 Aug 45
CALAWAY, GEORGE A.	Major	Oral dental Surgeon	22 Sep 42 - 10 Feb 43
		on MF Team	13 Jul 44 - 15 Aug 44
CALDWELL, GENE D.	Major	Orthopedic Surgeon	28 Sep 42 - 2 Aug 44
CANTLON, EDWIN L.	Major	General Surgeon	14 Apr 44 - 4 May 45
			4 Jul 45 - 23 Aug 45
CAVE, WILLIAM H.	Capt	Asst Gen Surgeon	22 Nov 44 - 14 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
CHANDLER, JOHN H.	Major	Asst Thor Surgeon	5 Oct 42 - 19 Feb 43
CHILDS, SAMUEL B.	Major	Asst Gen Surgeon	1 Nov 44 - 1 Feb 45
		General Surgeon	2 Feb 45 - 27 Aug 45
CHUNN, CHARLES F.	Major	General Surgeon	28 Sep 42 - 27 Aug 45
CLARK, HENRY B. JR.	Major	Maxillo Facial Surg	5 Oct 42 - 27 Aug 45
CLARK, ORVILLE R.	Major	General Surgeon	24 Sep 42 - 23 Mar 44
CONDIE, DOMINIC S.	Capt	Asst Gen Surgeon	1 Feb 45 - 20 Jul 45
CRANDELL, WALTER B.	Capt	Asst Gen Surgeon	11 May 44 - 26 Jan 45
CROSBY, WILLIAM D.	Capt	Asst Gen Surgeon	13 Sep 44 - 16 Jul 45
CUNNINGHAM, RALPH T.	Capt	OC Shock Team	6 Oct 42 - 7 Mar 43
		Asst Gen Surgeon	7 Mar 43 - 11 Jul 44
		General Surgeon	11 Jul 44 - 12 Oct 44
DEMPSEY, THOMAS F.	Major	Asst Gen Surgeon	10 Oct 42 - 13 Feb 43
DENT, PAUL L.	Major	General Surgeon	6 Jul 42 - 14 Feb 44
DONAGHY, GEORGE E.	Major	Anesthetist	5 Oct 42 - 27 Aug 45
DOUD, ERNEST A.	Capt	Anesthetist	11 Nov 42 - 27 Aug 45
DOUGHERTY, DANIEL V.	Capt	OC Shock Team	2 Dec 42 - 12 Mar 43
DOWMAN, CHARLES E.	Major	Neurosurgeon	16 Sep 42 - 27 Aug 45
DOZIER, ROBERT L. JR.	Capt	Asst Gen Surgeon	5 Feb 45 - 27 Aug 45
DRYE, JAMES C.	Capt	Anesthetist	9 Mar 44 - 27 Aug 45
DUGGAN, JOHN F.	Capt	Asst Gen Surgeon	27 Mar 45 - 20 Jul 45
EASLEY, CHARLES E. JR.	Capt	Asst Gen Surgeon	28 Dec 43 - 21 Feb 45
		General Surgeon	22 Feb 45 - 29 Mar 45
EDWARDS, WILLIAM C.	Capt	Orthopedic Surgeon	5 Oct 42 - 2 Feb 45
EMMI, ANTHONY J.	Capt	OC Shock Team	10 Oct 42 - 7 Mar 43
		Asst Gen Surgeon	7 Mar 43 - 27 Aug 45
ERVING, HENRY W.	Capt	Asst Neurosurgeon	31 Mar 45 - 20 Jul 45
EWING, WILLIAM M.	Major	Orthopedic Surgeon	22 Sep 42 - 11 Mar 44
FINEGOLD, JOSEPH	Capt	Asst Gen Surgeon	7 Mar 43 - 10 Apr 45
		General Surgeon	10 Apr 45 - 13 Jun 45
FIRESTEIN, BEN Z.	Capt	Anesthetist	28 Sep 42 - 27 Aug 45
FISCHER, IRVING C.	Capt	Asst Gen Surgeon	19 Apr 45 - 14 Jun 45
FISHWICK, DWIGHT B.	Major	General Surgeon	8 Dec 43 - 21 May 45
FITZPATRICK, LEO J.	Major	Anesthetist	24 Jun 42 - 22 Oct 44
FLOOD, CLYDE E.	Capt	Asst Gen Surgeon	7 Mar 43 - 5 Apr 44
FLYNN, GEORGE T.	Capt	Asst Gen Surgeon	2 Mar 44 - 27 Aug 45
FORSEE, JAMES H.	Colonel	Commanding Officer	2 May 42 - 27 Aug 45
FRANK, NORRIS H.	Major	Anesthetist	28 Sep 42 - 27 Aug 45
FULTON, HARRY L.	Capt	Asst Gen Surgeon	19 Apr 45 - 27 Aug 45
GARDNER, LYTT I.	1 Lt	OC Shock Team	4 Apr 45 - 19 Jun 45
GARLINGHOUSE, ROBERT O.	Major	General Surgeon	28 Sep 42 - 19 Sep 43
GAY, ELLERY C.	Major	Maxillo Surgeon	24 Sep 42 - 27 Aug 45
GIDDINGS, WOOSTER P.	Capt	Asst Gen Surgeon	16 Sep 42 - 7 Oct 44
		General Surgeon	7 Oct 44 - 27 Aug 45
GOSSLEE, JOHN M.	Capt	Asst Gen Surgeon	9 Feb 45 - 14 Jul 45
GRANTHAM, EVERETT G.	Capt	Neurosurgeon	22 Sep 42 - 16 Feb 43
GREENE, WARREN W.	Capt	Anesthetist	8 May 44 - 13 Jul 44
		Asst Gen Surgeon	13 Jul 44 - 25 Nov 44
		Anesthetist	25 Nov 44 - 28 Jun 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
GREENFIELD, JACK	Capt	Asst Thor Surgeon	7 Mar 43 - 28 Jun 43
		Asst Gen Surgeon	28 Jun 43 - 2 Mar 44
GREENSPON, SAMUEL E.	Capt	Anesthetist	13 Nov 44 - 14 Jun 45
GUMMESS, GLEN H.	Capt	Asst Gen Surgeon	7 Mar 43 - 4 Apr 45
		General Surgeon	4 Apr 45 - 27 Aug 45
GURVEY, JULIUS A.	Capt	Anesthetist	7 Mar 43 - 11 Jul 44
		Asst Gen Surgeon	11 Jul 44 - 27 Aug 45
HALL, FRANK W.	Major	General Surgeon	2 Oct 42 - 27 Aug 45
HAMILTON, ALFRED T.	Major	Asst Gen Surgeon	5 Oct 42 - 11 Feb 43
HAMILTON, THOMAS P.	Major	Asst Thor Surgeon	24 Sep 42 - 13 Feb 43
HARALSON, ROBERT H. JR.	Capt	Anesthetist	14 Apr 44 - 14 Aug 45
HART, WILLIAM W.	Capt	Anesthetist	28 Sep 42 - 26 Jun 45
HAUVER, RICHARD V.	Major	General Surgeon	24 Sep 42 - 27 Aug 45
HAYNES, LEIGH K.	Major	Maxillo Facial Surg	10 Oct 42 - 16 Sep 44
		Asst Gen Surgeon	16 Sep 44 - 16 Mar 45
		General Surgeon	16 Mar 45 - 31 Mar 45
HEAD, HOMER	Capt	OC Shock Team	28 Sep 42 - 2 Apr 43
		Asst Ortho Surgeon	2 Apr 43 - 12 Oct 43
HEANEY, HARRY G.	Capt	Asst Gen Surgeon	14 Nov 44 - 29 Mar 45
		Asst Ortho Surgeon	29 Mar 45 - 21 Apr 45
HERSTEIN, DAVID C.	Capt	Anesthetist	7 Mar 43 - 23 Feb 44
HICKS, DAVID Y. JR.	Capt	Asst Gen Surgeon	24 Sep 42 - 13 Feb 43
HIMMELSTEIN, AARON	Capt	Asst Thor Surgeon	26 Dec 42 - 7 Jul 43
		OC Shock Team	8 Jul 43 - 2 Aug 43
		Asst Gen Surgeon	3 Aug 43 - 7 Jun 45
HOBLER, ROSS E.	Capt	Asst Gen Surgeon	21 Sep 44 - 19 Aug 45
HOEFFDING, WALDEMAR	Capt	OC Gas Team	30 Nov 42 - 1 Oct 43
		Anesthetist	1 Oct 43 - 22 Apr 44
HOEFLICH, WERNER F. A.	Capt	Anesthetist	2 Oct 42 - 27 Aug 45
HOFFMAN, HENRY L.	Major	General Surgeon	22 Sep 42 - 27 Aug 45
HOFRICHTER, FRANK C.	Capt	Asst Ortho Surgeon	7 Mar 43 - 6 Jan 44
		Asst Gen Surgeon	6 Jan 44 - 4 Dec 44
		Asst Ortho Surgeon	4 Dec 44 - 29 Mar 45
		Asst Gen Surgeon	29 Mar 45 - 27 Jun 45
HOPKINS, GEORGE S.	Major	General Surgeon	28 Sep 42 - 27 Aug 45
HURT, LAWRENCE E.	Major	General Surgeon	22 Sep 42 - 8 Feb 45
HUTCHINS, PAUL F.	Capt	Anesthetist	4 Sep 42 - 13 Jul 44
		Asst Ortho Surgeon	13 Jul 44 - 8 Oct 44
		Asst Gen Surgeon	8 Oct 44 - 11 Jan 45
HYFER, HARRY J.	Capt	Anesthetist	4 Jul 44 - 19 Jul 45
IOVINE, VINCENT M.	Major	General Surgeon	9 Apr 44 - 21 May 45
IRONS, HARRY S. JR.	1 Lt		
JACOBSON, MURRAY B.	Capt	Anesthetist	10 Oct 42 - 12 Feb 44
JARVIS, FRED J.	Major	General Surgeon	22 Sep 42 - 26 Mar 45
JEANS, VIRGIL E.	Major	Asst Gen Surgeon	10 Oct 42 - 11 Feb 43
JERGESEN, FLOYD H.	Major	Orthopedic Surgeon	14 Sep 42 - 27 Jan 45
JONES, FLOYD H.	1 Lt	Asst Neurosurgeon	10 Oct 42 - 2 Feb 43
KAPLAN, IRWIN	Capt	Anesthetist	2 Mar 44 - 14 Aug 45
KARLIN, SAMUEL	Capt	Asst Gen Surgeon	12 Feb 43 - 16 Feb 43
KASMAN, LOUIS P.	Capt	Asst Gen Surgeon	11 Nov 42 - 13 Feb 43

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
KASTL, WILLIAM H.	Capt	Asst Gen Surgeon	5 Oct 42 - 10 Jul 43
		Asst Ortho Surgeon	10 Jul 43 - 23 Jan 44
		Asst Neurosurgeon	23 Jan 44 - 4 Jul 44
		Asst Gen Surgeon	4 Jul 44 - 14 Aug 45
KATZ, SIDNEY	Capt	Never joined	
KAY, RAYMOND M.	Capt	OC Shock Team	5 Oct 42 - 15 Oct 42
KENNEDY, FRANCIS J.	Capt	Anesthetist	2 Aug 43 - 11 Jul 44
KENNEDY, PAUL A.	Capt	Asst Gen Surgeon	22 Sep 42 - 1 Nov 44
		General Surgeon	1 Nov 44 - 27 Aug 45
KING, RICHARD	Capt	Asst Thor Surgeon	5 Oct 42 - 20 Feb 43
KLEMPERER, WOLFGANG W.	Capt	Asst Neurosurgeon	7 Mar 43 - 1 Feb 44
		Neurosurgeon	1 Feb 44 - 27 Aug 45
KNOTTS, FRANK L.	Capt	Asst Thor Surgeon	7 Mar 43 - 13 Jul 44
		Asst Gen Surgeon	13 Jul 44 - 28 Oct 44
KOCOUR, JAMES L.	Capt	Asst Gen Surgeon	7 Mar 43 - 9 Feb 44
KREIDER, JAMES A.	Major	Dental Prosthetist	14 Sep 42 - 27 Aug 45
LA CORE, IVAN A.	Capt	Asst Gen Surgeon	14 Sep 42 - 11 May 44
LADD, GRAHAM A.	1 Lt	Anesthetist	10 Oct 42 - 16 Feb 43
LALICH, JOSEPH J.	Capt	OC Shock Team	18 Oct 43 - 28 Mar 45
LATOFF, THOMAS J.	Capt	Asst Gen Surgeon	7 Mar 43 - 20 Feb 45
LAWRENCE, JOSEPH	Capt	Anesthetist	7 Mar 43 - 27 Aug 45
LAWRENCE, KNOWLES B.	Capt	Asst Gen Surgeon	10 Apr 45 - 27 Aug 45
LEAK, GLENN H.	Capt	Asst Gen Surgeon	11 Mar 44 - 27 Apr 44
LEES, WILLIAM M.	Capt	Asst Neurosurgeon	24 Sep 42 - 28 Jun 43
		Asst Thor Surgeon	28 Jun 43 - 27 Aug 45
LEGG, EUGENE P.	Capt	Asst Gen Surgeon	5 Oct 42 - 26 Oct 42
LEMMER, JOHN A. JR.	Capt	Asst Gen Surgeon	7 Mar 43 - 28 Jun 43
		OC Shock Team	28 Jun 43 - 2 Mar 44
LEVINS, HAROLD P.	Major	Dental Prosthetist	14 Sep 42 - 27 Aug 45
LOWRY, FORREST E.	Major	Asst Gen Surgeon	22 Sep 42 - 28 Jun 43
		General Surgeon	28 Jun 43 - 27 Aug 45
LOWRY, KENNETH F.	Major	General Surgeon	22 Sep 42 - 1 Nov 44
LYNCH, CORNELIUS G. JR.	Capt	Anesthetist	2 Oct 43 - 27 Aug 45
MAC MILLAN, HUGH A. JR.	Capt	Asst Gen Surgeon	2 Mar 44 - 31 Mar 45
		General Surgeon	31 Mar 45 - 7 Jun 45
MADDING, GORDON F.	Major	General Surgeon	22 Sep 42 - 27 Aug 45
MANSFIELD, WILLIAM K.	Major	Asst Gen Surgeon	18 Aug 42 - 28 Jun 43
		General Surgeon	28 Jun 43 - 5 Apr 44
MAPLE, JOHN L.	Capt	Anesthetist	13 Sep 44 - 27 Aug 45
MASON, JAMES M. III	Major	General Surgeon	5 Oct 42 - 27 Aug 45
MASSENGILL, FRANK C.	Capt	Asst Gen Surgeon	7 Mar 43 - 2 Apr 43
		OC Shock Team	2 Apr 43 - 2 Aug 43
		Asst Thor Surgeon	2 Aug 43 - 15 Jan 44
		Asst Ortho Surgeon	16 Jan 44 - 15 Jul 44
		Asst Gen Surgeon	16 Jul 44 - 18 Jan 45
MC DANIEL, JOHN R.	Capt	Asst Ortho Surgeon	11 Apr 44 - 13 Jul 44
		Asst Gen Surgeon	14 Jul 44 - 27 Aug 45
MC CLINTIC, MOSES H.	Capt	Asst Gen Surgeon	17 Sep 42 - 16 Feb 43

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
MICHELS, LEON M.	Major	Asst Gen Surgeon	28 Sep 42 - 17 Mar 44
		General Surgeon	18 Mar 44 - 27 Aug 45
MILLIGAN, PAUL R.	Capt	Asst Gen Surgeon	28 Sep 42 - 12 Jan 43
		Asst Ortho Surgeon	12 Jan 43 - 1 Jun 43
		Asst Gen Surgeon	1 Jun 43 - 13 Sep 44
		Orthopedic Surgeon	13 Sep 44 - 27 Aug 45
MITRANI, JACQUES H.	Capt	Asst Gen Surgeon	5 Oct 42 - 7 Mar 43
		General Surgeon	7 Mar 43 - 10 Oct 43
MOORE, HERBERT L.	Capt	Asst Gen Surgeon	5 Oct 42 - 7 Mar 43
		Asst Neurosurgeon	7 Mar 43 - 9 Mar 45
		Asst Gen Surgeon	9 Mar 45 - 27 Aug 45
MORRIS, JOHN F.	Capt	Anesthetist	7 Mar 43 - 20 Apr 44
MUSMAN, SAMUEL	Capt	Anesthetist	7 Mar 43 - 19 Feb 44
MUNSLOW, RALPH A.	Major	Neurosurgeon	28 Sep 42 - 3 Aug 44
NALL, HUBERT H.	Capt	Oral Dental Surgeon	28 Aug 42 - 17 Apr 44
		Oral Dental Surgeon	19 May 45 - 27 Aug 45
NATTINGER, JOHN K.	Major	Maxillo-Facial Surg	26 Dec 42 - 27 Aug 45
NELSON, WILLIAM A. JR.	Capt	Adjutant	9 May 42 - 27 Aug 45
NORQUIST, DONALD M.	Capt	Orthopedic Surgeon	10 Oct 42 - 18 Feb 43
OSHER, SEYMOUR L.	Capt	Anesthetist	28 Sep 42 - 16 Aug 45
PARK, BARTON E.	Major	General Surgeon	28 Sep 42 - 23 Jun 43
PARK, CHARLES L.	Major	General Surgeon	13 Jul 42 - 15 Aug 42
PLATT, EDWARD V.	Capt	Anesthetist	10 Apr 44 - 27 Aug 45
POOLE, HAROLD L.	Major	General Surgeon	24 Sep 42 - 27 Aug 45
PREISS, AARON	1 Lt		
ROBERTSON, ROBERT W.	Major	Asst Gen Surgeon	2 Oct 42 - 5 Apr 43
		General Surgeon	5 Apr 43 - 27 Aug 45
ROBINETT, JAMES B. JR.	Major	Anesthetist	22 Jul 44 - 10 Sep 44
ROBINSON, EDWARD B. JR.	Major	Anesthetist	10 Oct 42 - 27 Aug 45
ROSE, EDWARD E.	Major	Oral Surg MF Team	1 Aug 42 - 22 Nov 44
		Dental Prosthetist	22 Nov 44 - 27 Aug 45
ROSE, WILLIAM F.	Capt	Asst Thor Surgeon	13 Mar 44 - 16 Mar 44
		Asst Gen Surgeon	16 Mar 44 - 27 Mar 45
		General Surgeon	27 Mar 45 - 12 Jul 45
RUBNITZ, WILLARD	Capt	Asst Gen Surgeon	18 Oct 43 - 31 Jul 45
RUKKE, RAYMOND V.	Capt	Asst Gen Surgeon	29 Apr 45 - 12 Jul 45
RUSSELL, ALEXANDER F.	Major	General Surgeon	28 Sep 42 - 22 Feb 44
SAFER, JACOB B.	Capt	Asst Neurosurgeon	7 Mar 43 - 27 Sep 43
SAMSON, PAUL C.	Major	Thoracic Surgeon	28 Sep 42 - 27 Aug 45
SANDERS, RICHARD	Capt	Anesthetist	28 Sep 42 - 16 Feb 43
SAUNDERS, GEORGE R.	1 Lt		
SCHIFF, CHARLES A.	Capt	Asst Ortho Surgeon	7 Mar 43 - 31 Dec 43
		Asst Thor Surgeon	1 Jan 44 - 17 Aug 45
SCHNEIDERMAN, BENJAMIN I.	Capt	Anesthetist	7 Mar 43 - 27 Aug 45
SCHUSSHEIM, JOSEPH	Capt	OC, Shock Team	7 Mar 43 - 7 Jul 43
		Asst Gen Surgeon	7 Jul 43 - 10 Jan 44
		OC Shock Team	10 Jan 44 - 11 Mar 44
SEHLINGER, GEORGE A.	Capt	Anesthetist	22 Sep 42 - 16 Oct 44
SELLER, WILLIAM C.	Capt	Asst Gen Surgeon	5 Oct 42 - 13 Feb 43
SELDIN, STEWARD D.	Major	Oral Dental Surgeon	1 Aug 42 - 27 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
SHEFTS, LAWRENCE M.	Major	Thoracic Surgeon	28 Aug 42 - 27 Aug 45
SHEPARD, WARREN B. JR.	Capt	Asst Gen Surgeon	6 Apr 44 - 16 Nov 44
SHERIDAN, WILLIAM J.	Lt Col	Executive Officer	18 Aug 42 - 20 May 44
SHORBE, HOWARD B.	Major	Orthopedic Surgeon	10 Oct 42 - 5 Sep 44
SHORTZ, GERALD	Capt	Anesthetist	28 Sep 42 - 27 Aug 45
SHURE, ABRAHAM L.	Capt	Orthopedic Surgeon	14 Sep 42 - 10 Mar 44
SIEGAL, HENRY A.	Capt	Asst Neurosurgeon	5 Oct 44 - 4 Nov 44
		Asst Gen Surgeon	4 Nov 44 - 27 Dec 44
		Asst Neurosurgeon	28 Dec 44 - 18 Mar 45
		Asst Gen Surgeon	18 Mar 45 - 27 Aug 45
SITTLER, WERNER G.	Major	Oral Dental Surgeon	5 Oct 42 - 18 Jul 45
SMITH, CODE A.	1 Lt	Detachment CO	29 Aug 42 - 27 Aug 45
		Supply Officer	
		Transportation Off	
SNEIDERMAN, ROBERT	Capt	Anesthetist	7 Mar 43 - 7 Jun 45
STANDER, LEONARD	Major	Asst Gen Surgeon	22 Sep 42 - 13 Feb 43
STAUCH, OMAR A.	Capt	Asst Gen Surgeon	31 Mar 45 - 1 Aug 45
STEPHENSON, GEORGE W.	Major	General Surgeon	4 Nov 44 - 27 Aug 45
STERNBERG, JACOB C.	Major	Orthopedic Surgeon	14 Sep 42 - 2 Oct 42
STILL, RICHARD M.	Major	General Surgeon	8 Jul 42 - 13 Feb 43
STRAIT, JOHN M.	Capt	Anesthetist	17 Feb 45 - 14 Jun 45
SULLIVAN, JAMES M.	Lt Col	General Surgeon	28 Sep 42 - 30 Jun 44
		CO Detachment	20 Aug 44 - 13 Jun 45
		Executive Officer	14 Jun 45 - 27 Aug 45
SULLIVAN, ROBERT F.	Major	Oral Dental Surgeon	28 Aug 42 - 16 Jun 44
SWINDLER, CHARLES M.	Capt	OC Shock Team	5 Mar 44 - 13 Jul 44
		Asst Ortho Surgeon	13 Jul 44 - 10 Jan 45
		Asst Gen Surgeon	10 Jan 45 - 14 Jul 45
SWINGLE, HUGH F.	Major	Asst Gen Surgeon	5 Oct 42 - 7 Mar 43
		General Surgeon	7 Mar 43 - 27 Aug 45
SYDORIAK, WALTER L.	Capt	General Surgeon	14 Sep 42 - 4 May 43
		OC Shock Team	4 May 43 - 2 Mar 44
		Asst Gen Surgeon	2 Mar 44 - 20 Mar 44
TAYLOR, FLOYD D.	Major	Asst Gen Surgeon	24 Sep 42 - 11 Jan 44
		General Surgeon	11 Jan 44 - 27 Aug 45
THOMAS, JAMES J.	Capt	Asst Gen Surgeon	22 Sep 42 - 2 Oct 42
		Anesthetist	2 Oct 42 - 27 Aug 45
TINSLEY, MILTON	Major	Neurosurgeon	28 Sep 42 - 27 Aug 45
TOBEY, ALBRO	Capt	Asst Gen Surgeon	10 Apr 45 - 21 Jun 45
TOWERY, BEVERLY T.	Capt	OC Shock Team	31 Mar 44 - 27 Aug 45
VAN RIPER, WILLIAM D.	Capt	Asst Gen Surgeon	16 Mar 45 - 3 Aug 45
WALKER, OSCAR T. JR.	Major	Dental Prosthetist	14 Sep 42 - 27 Aug 45
WALSH, MAURICE J.	Capt	Asst Gen Surgeon	7 Mar 43 - 25 Aug 44
		Asst Executive Off	25 Aug 44 - 27 Aug 45
WARD, FRANCIS C.	Capt	Asst Gen Surgeon	24 Sep 42 - 13 Feb 43
WEISS, LEO	Capt	Anesthetist	27 Apr 44 - 24 Jun 45
WEISS, WILLIAM A.	Capt	Anesthetist	18 Sep 42 - 20 Mar 44
WELCH, JOHN D.	Capt	OC Shock Team	5 Mar 44 - 7 Jul 45
WESTERFIELD, CHARLES W.	Capt	Anesthetist	5 Oct 42 - 27 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
WESTON, CHARLES L.	Capt	OC Gas Team	30 Nov 42 - 27 Feb 44
		Asst Gen Surgeon	27 Feb 44 - 15 Nov 44
WILLIAMS, DONALD B.	Capt	Asst Thoracic Surg	16 Mar 44 - 1 Nov 44
		Thoracic Surgeon	1 Nov 44 - 16 Jul 45
WILSON, FREDRICK D.	Capt	Asst Gen Surgeon	10 Oct 42 - 8 Oct 44
		Asst Ortho Surgeon	8 Oct 44 - 4 Dec 44
		Asst Gen Surgeon	4 Dec 44 - 9 Mar 45
		Asst Neurosurgeon	9 Mar 45 - 27 Aug 45
WOLFF, LUTHER H.	Major	General Surgeon	5 Oct 42 - 27 Aug 45
WYLIE, ROBERT H.	Major	General Surgeon	16 Sep 44 - 27 Aug 45
ZURLO, DOMINICK A.	Capt	Anesthetist	7 Mar 43 - 4 May 43
		Asst Gen Surgeon	4 May 43 - 19 Apr 45
		General Surgeon	19 Apr 45 - 27 Aug 45
ALLINSON, CELIA	1 Lt	Nurse Op Room	24 Feb 43 - 1 Apr 45
BARNES, WILMA L.	1 Lt	Nurse Op Room	25 Feb 43 - 8 Jul 45
BECKER, IRENE C.	2 Lt	Nurse Anesthetist	22 Feb 43 - 16 Nov 44
BERRET, ANNA B.	1 Lt	Nurse Anesthetist	22 Feb 43 - 6 Jul 45
BOSS, RUTH E.	2 Lt	Nurse Op Room	22 Feb 43 - 30 Oct 43
BRIX, ANNE K.	1 Lt	Nurse Anesthetist	22 Feb 43 - 6 Jul 45
BROOKS, VIOLETTA A.	1 Lt	Nurse Op Room	23 Feb 43 - 7 May 45
CAMPBELL, MARY A.	1 Lt	Asst Chief Nurse	15 Jan 43 - 6 Jul 45
		Nurse Op Room	
CAMPO, AMANDA R.	2 Lt	Nurse Op Room	23 Feb 43 - 31 Mar 44
CARLISLE, FLORENCE M.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
COLLINS, ESTHER R.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
CONNOR, DORIS M.	2 Lt	Nurse Genl Duty	22 Feb 43 - 7 Jul 44
CONWAY, VALERA I.	2 Lt	Nurse Op Room	22 Feb 43 - 1 Dec 43
COOPER, AUDENE H.	1 Lt	Nurse Genl Duty	22 Feb 43 - 9 Jul 45
COX, DESSIE M.	1 Lt	Nurse Anesthetist	24 Feb 43 - 6 Jul 45
DAVIS, A. LAWRASON	1 Lt	Nurse Op Room	25 Feb 43 - 11 Aug 45
DAVIS, OPAL G.	1 Lt	Nurse Op Room	22 Feb 43 - 1 Feb 45
DICKSON, GROVA-NELLE	1 Lt	Nurse Op Room	22 Feb 43 - 1 Jan 45
DONAHOE, RHODA E.	1 Lt	Nurse Op Room	23 Feb 43 - 6 Jul 45
DRISCOLL, KATHRYN T.	1 Lt	Nurse Genl Duty	27 Feb 44 - 6 Jul 45
ELBERTSON, GLADYS H.	1 Lt	Nurse Op Room	17 Mar 45 - 6 Jul 45
ELLIOTT, CATHERINE V.	1 Lt	Nurse Op Room	2 Dec 43 - 9 Jul 45
ESCHENBERG, CHRISTINA M.	1 Lt	Nurse Op Room	17 Feb 44 - 6 Jul 45
ELSIK, BLANCHE A.	2 Lt	Nurse Op Room	22 Feb 43 - 12 Mar 44
FARQUHAR, LA VERNE	2 Lt	Nurse Op Room	23 Feb 43 - 10 Feb 44
FIRST, HELEN M.	2 Lt	Nurse Op Room	12 Oct 44 - 20 Oct 44
FISCHER, DOROTHY E.	1 Lt	Nurse Op Room	23 Feb 43 - 6 Jul 45
FLEMING, MILDRED N.	1 Lt	Nurse Genl Duty	22 Feb 43 - 6 Jul 45
GREGG, ETHEL M.	1 Lt	Nurse Op Room	24 Feb 43 - 6 Jul 45
GRINNELL, NORMA E.	2 Lt	Nurse Genl Duty	8 Jan 45 - 21 Apr 45
HARRELL, ISABEL G.	1 Lt	Nurse Op Room	24 Feb 43 - 6 Jul 45
HINDMAN, LAURA R.	1 Lt	Nurse Op Room	22 Feb 43 - 2 Mar 45
HINSHAW, ESTHER A.	1 Lt	Nurse Anesthetist	21 Dec 42 - 6 Jul 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
HUCKNALL, DORTHA M.	1 Lt	Chief Nurse	16 Jul 42 - 11 Mar 44
HUFF, M. MARGUERITE	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
JOHNSON, CHARLOTTE B.	1 Lt	Nurse Op Room	22 Feb 44 - 10 Oct 44
JOHNSTON, DENUM	2 Lt	Nurse Anesthetist	22 Feb 43 - 24 Nov 44
KIEREPKA, AGNES E.	1 Lt	Nurse Op Room	21 Feb 43 - 6 Jul 45
KIRK, EVELYN A.	1 Lt	Nurse Op Room	3 May 45 - 4 Jul 45
KRESS, JOSEPHINE A.	2 Lt	Nurse Op Room	18 Sep 42 - 18 Oct 42
LANG, HELEN L.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
LEGAKO, IRENE E.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
LENZ, MARY C.	2 Lt	Nurse Op Room	22 Feb 43 - 12 Mar 44
LINDSEY, ODESSA M.	1 Lt	Nurse Genl Duty	22 Feb 43 - 6 Jul 45
LOCKEMAN, FRANCES M.	1 Lt	Nurse Op Room	22 Feb 43 - 1 Feb 45
LOMBARDO, MARY E.	1 Lt	Nurse Anesthetist	23 Feb 43 - 6 Jul 45
MACOMBER, LOUISE F.	1 Lt	Nurse Op Room	28 Jan 45- 27 Jun 45
MARCOUX, SHIRLEY R.	1 Lt	Nurse Op Room	22 Feb 43 - 4 Jul 44
MATLOCK, MARY A.	1 Lt	Nurse Anesthetist	22 Feb 45 - 6 Jul 45
MAYSARROS, ANN	1 Lt	Nurse Anesthetist	25 Jun 44 - 6 Jul 45
MC DONALD, ANNA K.	1 Lt	Nurse Op Room	22 Feb 43 - 17 Mar 45
MELLA, MARGUERITE R.	1 Lt	Nurse Op Room	22 Feb 43 - 16 Feb 44
MIERNICKE, FRANCES A.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
MITCHELL, JOSEPHINE C.	2 Lt	Nurse Op Room	18 Sep 42 - 18 Oct 42
MOSHER, FRANCES L.	1 Lt	Nurse Op Room	22 Feb 43 - 9 Jul 45
MUHS, ELEANOR J.	1 Lt	Nurse Op Room	22 Feb 43 - 15 Jan 45
NEUBERT, GEORGIA E.	1 Lt	Nurse Genl Duty	22 Feb 43 - 6 Jul 45
NICHOLS, ELSIE M.	1 Lt	Nurse Genl Duty	22 Feb 43 - 12 Mar 44
O'BRIEN, MARY L.	2 Lt	Nurse Op Room	22 Feb 43 - 10 Dec 44
O'SHAUGHNESSY, MARIE J.	1 Lt	Nurse Anesthetist	22 Feb 43 - 13 Jul 45
PARRISH, JOSEPHINE C.	1 Lt	Nurse Op Room	24 Jun 44 - 6 Jul 45
PIETRZYK, WANDA C.	1 Lt	Nurse Op Room	25 Feb 43 - 6 Jul 45
PIZZOLATTO, LENA C.	1 Lt	Nurse Op Room	23 Feb 43 - 6 Jul 45
PONKO, RUTH	2 Lt	Nurse Op Room	25 Feb 43 - 26 Oct 44
PRATHER, EDITH W.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
PRICE, IDA G.	Capt	Chief Nurse	25 Feb 44 - 16 Aug 45
RANDOLPH, MARY W.	1 Lt	Nurse Op Room	23 Feb 43 - 9 Feb 45
RHEAUME, JULIANNE M.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
RICKERT, HELEN B.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
ROGERS, HILDA E.	1 Lt	Nurse Anesthetist	22 Feb 43 - 6 Jul 45
RODRIGUEZ, JOSEFINA M.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
RODMAN, CATHRINE M.	2 Lt	Nurse Op Room	24 Feb 43 - 12 Feb 44
RYAN, MARGARET M.	1 Lt	Nurse Op Room	24 Feb 44 - 3 Jul 45
SHEARER, MARY V.	1 Lt	Nurse Op Room	22 Feb 43 - 25 Feb 45
SHOCKCOR, MARGARET B.	1 Lt	Nurse Anesthetist	31 Mar 45 - 6 Jul 45
SMITH, ANNA M.	2 Lt	Nurse Genl Duty	25 Feb 43 - 8 Feb 45
SMITH, MARIE J.	1 Lt	Nurse Anesthetist	20 Apr 45 - 6 Jul 45
SOBECK, RUTH C.	1 Lt	Nurse Genl Duty	22 Feb 43 - 6 Jul 45
STURNIOLO, BERNARDINE N.	1 Lt	Nurse Op Room	26 Feb 44 - 5 Jul 45
STRATTON, LINA J.	1 Lt	Nurse Op Room	22 Feb 43 - 6 Jul 45
SWAB, MARY E.	1 Lt	Nurse Op Room	23 Feb 43 - 6 Jul 45
THOMAS, MARTHA G.	1 Lt	Nurse Genl Duty	22 Feb 43 - 9 Jul 45
TUFFLEY, EDNA E.	1 Lt	Nurse Op Room	28 Jan 45 - 6 Jul 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
URBAN, STACIA	2 Lt	Nurse Op Room	18 Sep 42 - 18 Oct 42
USNIK, MARY A.	1 Lt	Nurse Op Room	25 Feb 43 - 9 Jul 45
VILLALBA, LOLA	1 Lt	Nurse Op Room	28 Jan 45 - 9 Jul 45
VERAZIN, BETTY F.	1 Lt	Nurse Op Room	22 Feb 43 - 9 Jul 45
WATKINS, JANE E.	2 Lt	Nurse Op Room	18 Sep 42 - 18 Oct 42
WHIMPEY, GENEVIEVE L.	1 Lt	Nurse Op Room	7 Feb 45 - 3 Jul 45
Adkins, McCoy P.	T/4	Utility Repairman	8 May 44 - 27 Aug 45
Aldridge, Elias V.	Pvt	Basic	13 Feb 43 - 5 Jul 45
Anderson, Herman J.	T/5	Driver	8 Jan 43 - 27 Aug 45
Antico, Joseph	T/5	Surgical Technivian	21 Jan 45 - 9 Aug 45
Arnold, Omar W.	T/4	Surgical Technician	3 Oct 42 - 4 Jan 44.
		Section Leader	4 Jan 44 - 6 Jan 45
Ashburn, James W.	T/4	Clerk Typist	4 Feb 43 - 27 Aug 45
Austin, Willard R.	T/5	Carpenter General	13 Feb 43 - 4 Jul 45
Bailey, Donald A.	Pfc	Dental Technician	12 Jan 45 - 11 Apr 45
		Surgical Technician	11 Apr 45 - 27 Aug 45
Ballard, Waynewright A.	T/4	Mechanic Automotive	25 Sep 42 - 27 Aug 45
Barnett, Edgar E.	Pvt	Surgical Technician	6 Oct 42 - 12 Jun 44
Barthold, Ottomar J.	T/4	Clerk Typist	28 Jul 42 - 21 Aug 43
Bartlett, Edgar W.	T/4	Surgical Technician	28 Jul 42 - 27 Aug 45
Basinski, Eugene R.	T/5	Med. Lab. Techn	14 Jan 45 - 27 Aug 45
Batongelo, John A.	T/4	Clerk Typist	18 Aug 44 - 27 Aug 45
Berry, Clifford W.	T/5	Surgical Technician	4 Feb 43 - 28 Apr 45
Berube, Armand L.	T/4	Dental Technician	29 Sep 42 - 27 Aug 45
Bieber, Mathias J.	T/5	Surgical Technician	15 Aug 42 - 27 Aug 45
		Cook	
Biggs, Thomas H.	Pfc	Surgical Technician	13 Feb 43 - 15 Jun 44
Bowerman, Ben E.	T/4	Clerk Typist	15 Jul 42 - 13 Feb 43
Braccia, Amedeo	T/5	Surgical Technician	10 Jan 45 - 9 Aug 45
Brady, Joseph T.	Pvt	Surgical Technician	1 Mar 44 - 27 Aug 45
Brickman, Samuel P.	Pfc	Surgical Technician	5 Nov 42 - 13 Feb 43
Broda, John H.	T/4	Surgical Technician	15 Aug 42 - 27 Aug 45
Burbridge, Lynn L.	Pfc	Surgical Technician	6 Oct 42 - 27 Aug 45
Budzynski, Casimer T.	Pvt	Medical Technician	28 Jul 42 - 14 Oct 44
Burghardt, Robert L.	T/5	Surgical Technician	8 Jan 43 - 27 Aug 45
		Driver	
Burns, Francis J.	T/5	Dental Technician	28 Jul 45 - 27 Aug 45
Buse, Jessie L.	Pfc	Surgical Technician	3 Oct 42 - 27 Aug 45
Cady, Clayton F.	T/4	Surgical Technician	16 Apr 43 - 10 Feb 44
Capalbo, Louis D.	T/5	Surgical Technician	28 Jul 42 - 27 Aug 45
Carty, John F.	T/5	Surgical Technician	28 Jul 42 - 22 Mar 45
Chiara, Thomas J.	Pvt	Surgical Technician	1 Mar 44 - 25 Jul 44
Clark, George W.	T/5	Surgical Technician	2 Oct 42 - 27 Aug 45
Cohen, Abe	Pvt	Basic	4 Feb 43 - 23 Dec 43
Collins, Cecil C.	T/4	Surgical Technician	6 Oct 42 - 14 Jun 45
Collins, Robert M.	T/4	Clerk Typist	31 Oct 44 - 27 Aug 45
Cornell, Warren I.	Pvt	Basic	4 Feb 43 - 17 Feb 43

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
Curin, Clifford J.	Pfc	Surgical Technician	23 Oct 42 - 13 May 43
Cusumano, Philip	S/Sgt	Supply Sergeant	10 Apr 42 - 27 Aug 45
Dalton, Leonard J.	Pfc	Surgical Technician	29 Mar 45 - 9 Aug 45
Davidson, Arthur H.	T/4	Surgical Technician	5 Jan 45 - 9 Aug 45
Davidson, Charles C.	Pfc	Driver	15 Aug 42 - 27 Aug 45
Davis, Gilbert I.	T/5	Surgical Technician	11 Sep 42 - 11 Jan 43
Delorey, George A.	Pfc	Surgical Technician	2 Oct 42 - 9 Jul 45
Dettore, William E.	Pfc	Surgical Technician	3 Oct 42 - 6 Nov 43
Dixon, Thomas L.	T/4	Surgical Technician	3 Oct 42 - 27 Aug 45
Dobbelaar, Ransom H.	T/3	Surgical Technician	14 Oct 42 - 12 Apr 44
Douglass, Wayne B.	T/5	Surgical Technician	6 Oct 42 - 9 Aug 45
Dreiss, Frederick A.	1st Sgt	Medical Technician	28 Jul 42 - 1 May 43
		Section Leader	1 May 43 - 10 Aug 45
		1st Sergeant	10 Aug 45 - 27 Aug 45
Dunlap, Loyd L.	T/5	Surgical Technician	3 Oct 42 - 19 Jul 44
Edmunds, Sidney C.	T/5	Surgical Technician	2 Oct 42 - 21 May 45
Edwards, William O.	T/4	Surgical Technician	15 Aug 42 - 9 Aug 45
Egnaczewski, Julian Jr.	T/4	Surgical Technician	28 Jul 42 - 22 Jan 44
		Section Leader	22 Jan 44 - 27 Aug 45
Ellingson, Orlando J.	Pfc	Basic	6 Oct 42 - 13 Feb 43
Ellis, Jimmy M.	Pfc	Surgical Technician	3 Oct 42 - 28 Feb 45
Emott, Edward M.	T/5	Surgical Technician	2 Oct 42 - 4 Sep 44
Esposito, Gennarao G.	Pfc	Dental Technician	31 Oct 44 - 9 Aug 45
Feil, David P.	T/5	Medical Technician	6 Oct 42 - 27 Aug 45
Feingold, Samuel	T/5	Surgical Technician	4 Feb 43 - 27 Aug 45
Fisher, George B.	T/5	Surgical Technician	19 Jun 44 - 27 Aug 45
Frankel, Sidney	T/5	Surgical Technician	11 Sep 42 - 27 Aug 45
Frankenberg, Frederick F.	T/5	Dental Technician	8 Jan 43 - 9 Aug 45
Frederick, Arthur H.	Pfc	Dental Technician	31 Oct 44 - 27 Aug 45
Freedman, George I.	Pfc	Surgical Technician	31 Oct 44 - 9 Aug 45
Frick, Henry	T/5	Surgical Technician	19 Jun 43 - 27 Aug 45
Friedland, Ira M.	T/4	Medical Technician	26 Jun 42 - 27 Aug 45
Gallo, Octavio A.	T/4	Dental Technician	11 Sep 42 - 27 Aug 45
Gardiner, Frank R.	T/5	Dental Technician	31 Oct 44 - 9 Aug 45
Garvey, Vernice L.	T/4	Dental Technician	8 Jan 43 - 27 Aug 45
Gaughran, Bernard	T/4	Dental Technician	28 Jul 42 - 27 Aug 45
George, James R.	Pvt	Basic	13 Feb 43 - 23 Dec 43
Gillum, Harold A.	T/4	Utility Repairman	6 Oct 42 - 27 Aug 45
Glicksman, Martin	Pfc	Med. Lab Techn	14 Jan 45 - 10 Aug 45
Goodwin, Lester M.	T/4	Surgical Technician	28 Jul 42 - 9 Aug 45
Gore, Glenwood W.	Pfc	Basic	9 Feb 43 - 10 Jul 45
Greer, Wilbur C.	T/4	Surgical Technician	3 Oct 42 - 9 Jul 45
Gregory, Robert R.	T/5	Clerk General	28 Jul 42 - 27 Aug 45
Grosse, Stanley	Pvt	Basic	11 Sep 42 - 12 Nov 42
Gueriskie, Joseph J.	Pvt	Basic	28 Jul 42 - 21 Apr 43
Gunderson, Ervin V.	T/5	Surgical Technician	6 Oct 42 - 26 Aug 45
Gutzman, Walter C.	Pvt	Basic	6 Oct 42 - 11 Feb 43
Hadl, Richard J.	T/5	Surgical Technician	28 Jul 42 - 27 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
Halpin, Francis W.	T/5	Surgical Technician	21 Aug 44 - 9 Aug 45
Handley, Joe l.	T/5	Dental Technician	8 Jan 43 - 9 Aug 45
Hannah, Walter W.	T/5	Surgical Technician	3 Oct 42 - 5 Jul 45
Harmon, Charles W.	Pvt	Basic	6 Oct 42 - 19 Jan 43
Hasenwinkel, Ewaldt F.	T/5	Surgical Technician	6 Oct 42 - 3 Aug 44
Haun, Carl E.	Pfc	Medical Technician	28 Jul 42 - 5 Jul 45
Higuchi, Paul H.	Pvt	Basic	4 Nov 42 - 11 Aug 43
Hinrichs, Rolland C.	T/4	Clerk Typist	6 Oct 42 - 27 Aug 45
Hoeler, William F.	T/4	Surgical Technician	28 Jul 42 - 10 May 44
Holtschlag, Walter E.	T/5	Driver	6 Oct 42 - 27 Aug 45
Holtz, Otto A.	T/5	Mail Clerk	15 Jul 42 - 27 Aug 45
Honeycutt, Walter T.	T/5	Surgical Technician	3 Oct 42 - 1 May 45
Honigman, Benjamin	T/4	Pharmacist	11 Sep 42 - 27 Aug 45
Horine, Floyd M.	Pfc	Surgical Technician	29 Mar 45 - 9 Aug 45
Hornstein, Pius	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
House, Richard C.	Pfc	Basic	6 Oct 42 - 27 Aug 45
Hudzik, Walter J.	T/5	Basic	6 Oct 42 - 27 Aug 45
Iverson, Glennie J.	T/5	Surgical Technician	6 Oct 42 - 27 Aug 45
Jabkiewicz, Frank J.	T/5	Surgical Technician	6 Oct 42 - 12 May 45
Jackson, John T.	Pvt	Surgical Technician	6 Oct 42 - 14 Feb 44
Johnsmeyer, Earl W.	T/4	Clerk Typist	18 Aug 44 - 23 Nov 44
Johnson, Robert E.	T/5	Surgical Technician	2 Oct 42 - 4 Sep 44
Johnson, Wallace R.	T/5	Supply Clerk	8 Jan 43 - 11 May 44
		Surgical Technician	11 May 44 - 27 Aug 45
Karathanasis, Zafiris J.	T/5	Surgical Technician	28 Jul 42 - 9 Aug 45
Kargol, Joseph	T/5	Medical Technician	6 Oct 42 - 27 Aug 45
Kempner, Frank S.	T/5	Surgical Technician	3 Oct 42 - 5 Jul 45
Kennedy, Jerome	Pvt	Basic	13 Feb 43 - 19 Jun 43
King, Robert W.	T/5	Surgical Technician	4 Feb 43 - 27 Aug 45
Kiwimagi, Floyd	Pvt	Basic	11 Sep 42 - 13 Feb 43
Knight, William B. Jr.	T/5	Surgical Technician	9 Feb 43 - 27 Aug 45
Koch, William P.	S/Sgt	Chief Clerk	28 Jul 42 - 27 Aug 45
Koshland, Milton P. Jr.	T/5	Surgical Technician	28 Jul 42 - 12 Apr 44
Kramer, David M.	Pfc	Basic	28 Jul 42 - 11 Jan 43
Krieger, Norman H.	T/4	Mail Clerk	28 Jul 42 - 27 Aug 45
Krum, Clifford G.	T/4	Transportation NCO	15 Aug 42 - 7 Jan 44
		Surgical Technician	8 Jan 44 - 14 Jul 44
LaGrande, Joseph S.	Pvt	Basic	15 Apr 42 - 13 Feb 43
Lamb, Ellis G.	Sgt	Surgical Technician	3 Oct 42 - 14 Jun 45
Larson, Kenneth L.	T/5	Surgical Technician	5 Jan 45 - 9 Aug 45
LeBeau, Benjamin A.	Pfc	Basic	10 Oct 42 - 13 Feb 43
Lefkowitz, Ben	T/5	Surgical Technician	4 Feb 43 - 12 May 45
Leiderman, Nathaniel H.	T/5	Surgical Technician	28 Jul 42 - 12 Jun 44
LeSaux, Henri A.	Pvt	Cook	28 Jul 42 - 23 Dec 43
Leslie, Simeon R.	T/5	Surgical Technician	6 Oct 42 - 27 Aug 45
Levine, Herbert	T/4	Surgical Technician	28 Jul 42 - 29 Mar 44
Levitt, Samuel	T/5	Surgical Technician	28 Jul 42 - 13 Feb 43
Linamen, John R.	T/5	X-ray Technician	31 Oct 44 - 9 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
Lingerfelt, Benjamin L.	T/4	Surgical Technician	3 Oct 42 - 2 Jul 45
Looney, Frank M.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
Lotz, Ted B.	T/5	Surgical Technician	2 Oct 42 - 5 Jul 45
Ludewig, Benjamin C.	T/4	Mechanic Automotive	6 Oct 42 - 27 Aug 45
Mack, William	Pvt	Dental Technician	31 Oct 44 - 9 Aug 45
Mahnken, Henry Jr.	Sgt	Section Leader	28 Jul 42 - 12 Jul 44
		Surgical Technician	13 Jul 44 - 27 Aug 45
Malnick, Morris	T/5	Surgical Technician	14 Oct 42 - 20 Mar 44
Martin, Harry R. Jr.	T/4	Surgical Technician	3 Oct 42 - 22 Aug 43
Martin, John P.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
McAneney, John	Pfc	Surgical Technician	28 Jul 42 - 27 Aug 45
McCarthy, Peter R.	T/4	Surgical Technician	28 Jul 42 - 27 Aug 45
McClung, Herman R.	T/5	Surgical Technician	8 Jan 43 - 27 Aug 45
McCombs, Theron G.	T/5	Surgical Technician	6 Oct 42 - 31 Jan 44
McDonald, Joseph F.	Pfc	Basic	28 Jul 42 - 27 Aug 45
McElwain, John H. Jr.	Pfc	Basic	13 Feb 43 - 5 Jul 45
McGuckin, Walter J.	T/5	Cook	28 Jul 42 - 27 Aug 45
McGuire, William H.	T/5	Surgical Technician	28 Jul 42 - 27 Aug 45
McKean, Don D.	T/5	Surgical Technician	8 Jan 43 - 9 Aug 45
McLaughlin, Vern E.	T/4	Surgical Technician	3 Oct 42 - 9 Aug 45
Meigs, Walter Jr.	Pfc	Surgical Technician	28 Jul 42 - 27 Aug 45
Meisinger, Alfred D.	T/5	Cook	6 Oct 42 - 29 Dec 43
Mikula, Frank	T/5	Surgical Technician	5 Nov 42 - 27 Aug 45
Miller, Charles	Pvt	Basic	28 Jul 42 - 26 Feb 43
Murphy, Patrick F.	T/5	Surgical Technician	3 Oct 42 - 5 Jul 45
Myers, Doyle C.	T/5	Surgical Technician	5 Jan 45 - 9 Aug 45
Neidhart, Edward A.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
Nemmert, Paul A.	T/4	Surgical Technician	28 Jul 42 - 27 Aug 45
Netterville, Edward A.	Pvt	Basic	15 Aug 42 - 13 Feb 43
Nietzer, George A.	T/5	Surgical Technician	28 Jul 42 - 21 Aug 43
Nintemann, William E.	Pfc	Basic	6 Oct 42 - 29 Dec 43
Norris, Emmett	Pvt	Surgical Technician	6 Oct 42 - 27 Jan 45
Oakes, Kenneth T.	T/5	Dental Technician	4 Feb 43 - 27 Aug 45
Oatman, Harry L.	Pvt	Surgical Technician	28 Jul 42 - 15 Oct 43
Odermann, Alfred A.	T/4	Surgical Technician	6 Oct 42 - 22 Aug 45
Oleson, Edward	T/5	Surgical Technician	6 Oct 42 - 2 Jul 45
Olivarez, Avelino D.	Cpl	Surgical Technician	31 Oct 44 - 9 Aug 45
Ordway, Durman A.	T/4	Driver	6 Oct 42 - 27 Aug 45
Overturf, Orval E.	T/5	Surgical Technician	6 Oct 42 - 19 Apr 44
Pacelli, Louis J.	T/5	Surgical Technician	11 Sep 42 - 27 Aug 45
Palumbo, Salvatore L.	T/5	Surgical Technician	11 Aug 42 - 27 Aug 45
Pantlen, Albert W. Jr.	T/5	Surgical Technician	28 Jul 42 - 21 Apr 44
Parisella, Rosario J.	T/4	Cook	28 Jul 42 - 27 Aug 45
Payne, Raymond J.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
Peaney, Alfred J.	Pvt	Basic	11 Sep 42 - 13 Dec 43
Petagno, Anthony	T/5	Surgical Technician	28 Jul 42 - 13 Feb 43
Peyer, Albert W.	T/4	Clerk Typist	6 Oct 42 - 27 Aug 45
Pinto, John Jr.	T/5	Surgical Technician	17 Jun 44 - 9 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
Popowsky, Nathan	Pfc	Surgical Technician	11 Sep 42 - 27 Aug 45
Postanowicz, Joseph J.	T/4	Dental Technician	15 Aug 42 - 27 Aug 45
Potocki, Allix	T/4	Surgical Technician	3 Oct 42 - 6 Apr 44
Privitera, Dominick	T/5	Surgical Technician	11 Sep 42 - 27 Aug 45
Radovich, Edward J.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
Ramirez, Jose	T/4	Surgical Technician	3 Oct 42 - 5 Jul 45
Randolph, Paul	T/4	Surgical Technician	2 Oct 42 - 14 Jun 45
Reller, Henry J.	T/4	Dental Technician	6 Oct 42 - 27 Aug 45
Rendle, William G.	Pvt	Basic	11 Sep 42 - 20 Dec 42
Richardson, Robert O.	Pvt	Cook	10 Apr 42 - 13 Feb 43
Richelson, Joseph	Pfc	Surgical Technician	1 Mar 44 - 27 Aug 45
Ricci, John C.	T/4	Surgical Technician	4 Feb 43 - 11 May 44
		Supply Clerk	12 May 44 - 1 Jul 45
Ricketts, Lyle R.	T/5	Dental Technician	7 Jan 43 - 10 Aug 44
Riley, Alfred E.	T/4	Surgical Technician	1 Oct 42 - 6 Oct 44
Riley, William G.	T/5	Dental Technician	11 Sep 42 - 27 Aug 45
Roberts, John F.	S/Sgt	Surgical Technician	14 Oct 42 - 4 Sep 43
Romano, George L.	T/4	Medical Technician	28 Jul 42 - 21 Aug 43
Romano, Quindo G.	T/5	Surgical Technician	6 Oct 42 - 9 Aug 45
Rood, Carl O.	Pvt	Basic	6 Oct 42 - 19 Jan 43
Roper, Hubert L.	Pvt	Utility Repairman	13 Feb 43 - 23 Dec 43
Rothwell, Kelley	T/5	Clerk Typist	6 Jan 43 - 27 Aug 45
Ruth, Raymond C.	Pfc	Cook	6 Oct 42 - 27 Aug 45
Rutka, Frank J.	T/5	Surgical Technician	10 Jan 45 - 27 Aug 45
Ryan, William H.	T/4	Surgical Technician	3 Oct 42 - 2 May 44
Rymarski, Boleslaw J.	T/5	Surgical Technician	11 Sep 42 - 27 Aug 45
Salzberg, Hugh W.	T/5	Clerk	8 Jun 44 - 15 Apr 45
Sanders, Edward P.	T/5	Cook	15 Jul 42 - 27 Aug 45
Scarpitti, Alfred J.	T/5	Supply Clerk	9 Jan 45 - 9 Aug 45
Schettley, Adam J.	T/5	Supply Clerk	15 Jul 42 - 27 Aug 45
Schneeweiss, Edward E.	T/4	Surgical Technician	11 Sep 42 - 2 Jul 45
Schweda, Edwin F.	T/5	Medical Technician	6 Oct 42 - 26 Aug 44
		Mail Clerk	27 Aug 44 - 27 Aug 45
Scott, Donald R.	T/4	Surgical Technician	17 Feb 43 - 1 Nov 44
		Mechanic Automotive	2 Nov 44 - 27 Aug 45
Scott, Vernon A.	T/5	Surgical Technician	6 Oct 42 - 27 Aug 45
Seale, Franklin D.	T/3	Surgical Technician	30 Sep 42 - 12 May 45
Semivan, John	T/4	Surgical Technician	3 Oct 42 - 12 May 45
Sheridan, Julian R.	T/5	Dental Technician	6 Oct 42 - 27 Aug 45
Sidote, Anthony L.	Pvt	Basic	10 Jan 45 - 27 Aug 45
Simmons, Otha H.	T/5	Surgical Technician	6 Oct 42 - 27 Aug 45
Sims, Leroy	T/5	Surgical Technician	26 Feb 45 - 27 Aug 45
Skalicky, Wencil	Pfc	Basic	15 Jul 42 - 27 Aug 45
Slavik, Paul A.	T/4	Surgical Technician	2 Oct 42 - 9 Jul 45
Small, George L.	Pvt	Basic	10 mApr 42 - 30 Jul 42
Smith, Alvin O.	Pvt	Basic	15 Jul 42 - 13 Feb 43
Smith, Franklin R.	1st Sgt	1st Sergeant	15 Jul 42 - 9 Aug 45

ROSTER OF ASSIGNED PERSONNEL 2ND AUXILIARY SURGICAL GROUP CONT'D

NAME	RANK	DUTY	DATES
Smith, Richard C.	Pvt	X-ray Technician	28 Jul 42 - 13 Feb 43
Sorroll, Alton P.	Pvt	Basic	11 Aug 42 - 13 Feb 43
Sperbeck, Lewis C.	T/5	Driver	15 Aug 42 - 27 Aug 45
Spicker, Adolph F.	T/5	Surgical Technician	14 Oct 42 - 21 Apr 44
Spurgiasz, Stanley	Pvt	Cook	28 Jul 42 - 9 Nov 44
Staley, James H.	T/4	Cook	10 Apr 42 - 12 May 45
Stratos, Gus	T/5	Baker	28 Jul 42 - 27 Aug 45
Stoner, Bertram	T/4	Surgical Technician	11 Sep 42 - 27 Aug 45
Styles, Ben F. Jr.	Pfc	Surgical Technician	2 Oct 42 - 1 Mar 45
Sutyak, Frank J.	T/5	Surgical Technician	6 Oct 42 - 27 Aug 45
Swann, James C.	Pvt	Basic	11 Sep 42 - 13 Feb 43
Swirep, Henry P.	Pvt	Surgical Technician	5 Jan 45 - 27 Aug 45
Teal, Guy E. Jr.	T/4	Surgical Technician	3 Oct 42 - 9 Aug 45
Tignanelli, Ernest L.	T/4	Surgical Technician	3 Oct 42 - 9 Jul 45
Todd, Glenn L.	T/4	Surgical Technician	6 Oct 42 - 28 Sep 43
Trautner, Adalbert J.	T/4	Surgical Technician	6 Oct 42 - 27 Aug 45
Tsinzo, Harry	Pfc	Surgical Technician	10 Jan 45 - 27 Aug 45
Vaughan, Percy E.	Pfc	Surgical Technician	11 Sep 42 - 13 Feb 43
Vikingstad, Fred	T/5	Surgical Technician	30 Sep 42 - 13 Feb 43
Voss, Charles J.	T/4	Surgical Technician	3 Oct 42 - 27 Aug 45
Wagner, Charles J.	Pvt	Basic	28 Jul 42 - 29 Sep 42
Wallace, James E.	T/5	Surgical Technician	6 Oct 42 - 8 Feb 45
Walker, Jack E.	S/Sgt	Mess Sergeant	10 Apr 42 - 14 Jun 45
Walker, Robert J.	Sgt	Surgical Technician	16 Aug 44 - 27 Aug 45
Weaver, Eugene	T/4	Surgical Technician	3 Oct 42 - 9 Aug 45
Weaver, William J.	T/5	Surgical Technician	28 Sep 42 - 9 Aug 45
Welinsky, Henry G.	T/5	Surgical Technician	28 Jul 42 - 21 Apr 44
Welborn, Keith V.	T/5	Surgical Technician	30 Sep 42 - 27 Aug 45
Welling, Henry	T/5	Cook	4 Feb 43 - 27 Aug 45
White, Francis J.	T/5	Clerk Typist	18 Aug 44 - 7 Jul 45
Wilhelmy, Fred J.	T/5	Surgical Technician	11 Sep 42 - 27 Aug 45
Williams, John H.	T/4	Surgical Technician	2 Oct 42 - 9 Aug 45
Williams, Michael T.	T/4	Surgical Technician	11 Sep 42 - 27 Aug 45
Wilson, James E.	1st Sgt	1st Sergeant	10 Apr 42 - 26 Sep 42
Wilson, Max A.	T/5	Surgical Technician	18 Oct 42 - 20 Mar 44
Windsor, Thomas	T/5	Surgical Technician	14 Oct 42 - 20 May 43
Wojciechowski, Joseph F.	T/5	Surgical Technician	17 Jun 44 - 9 Aug 45
Wornson, Ralph G.	T/5	Dental Technician	6 Oct 42 - 27 Aug 45
Yardley, Edwin L.	Pfc	Basic	6 Oct 42 - 27 Aug 45
Zelmer, Edward E.	Pfc	Basic	6 Oct 42 - 27 Aug 45
Zirkle, George E.	T/4	Cook	8 Jan 43 - 27 Aug 45

AWARDS

and

DECORATIONS

B-A-T-T-L-E H-O-N-O-R-S

TUNISIAN CAMPAIGN	NORTH APENNINES CAMPAIGN
SICILIAN CAMPAIGN	PO VALLEY CAMPAIGN
NAPLES FOGGIA CAMPAIGN	SOUTHERN FRANCE CAMPAIGN
ROME ARNO CAMPAIGN	RHINELAND CAMPAIGN

CENTRAL EUROPEAN CAMPAIGN

CITATION

MERITORIOUS SERVICE UNIT PLAQUE

THE 2D AUXILIARY SURGICAL GROUP is awarded the Meritorious Service Unit Plaque for superior performance of duty in the accomplishment of exceptionally difficult tasks from 1 September to 31 October 1944, in Italy. Operating within enemy artillery range and under severe weather conditions, this unit displayed steadfast devotion to duty in the surgical management of the seriously wounded, greatly increasing the expectancy of survival by performing major surgery close to the field of battle. The unparalleled degree of technical skill and tireless energy of the personnel of the 2d Auxiliary Surgical Group resulted in the saving of countless lives of American and Allied Soldiers. The noteworthy accomplishments of this organization reflect credit on the Medical Corps of the United States Army.

Published in Section VI, General Order No. 39, Hq Fifth Army, on 9 April 1945.

DISTINGUISHED-SERVICE CROSS

JOHN E. ADAMS, (0345350), Major, Medical Corps, United States Army. For extraordinary heroism in action, on 24 January 1944. Major ADAMS was aboard a hospital carrier which was bombed by enemy planes twenty miles off shore. After other personnel had left for the upper decks he voluntarily returned to the resuscitation ward to evacuate seriously wounded patients who were unable to escape. The ship rapidly sank, and as a result of his selfless concern for the welfare of his patients, Major ADAMS is missing in action. His profound courage in the face of certain death reflects the heroic traditions of the Medical Corps of the United States Army. Entered military service from Lynchburg, Virginia. Next of kin: Mrs. Helene M. Adams (Wife), Hallock, Minnesota.

Published in Section I, General Order No. 52, Hq Fifth Army, on 28 March 1944.

LEGION OF MERIT MEDAL

1st Lt. Wilma L. Barnes
Major Reeve H. Betts
Major Thomas H. Burford
1st Lt. Mary A. Campbell
Colonel James H. Forsee
Major Richard V. Hauver
Lt. Col. Kenneth F. Lowry
Major James H. Mason III
Major Harold L. Poole
Major Edward B. Robinson, Jr.
Major Paul C. Samson
Lt. Col. James M. Sullivan
Major Luther H. Wolff
Sgt. Ellis G. Lamb
Tec 4 Frank N. Looney
1st Sgt. Franklin R. Smith

SILVER STAR MEDAL

Captain Joseph F. Barrett
Captain William H. Cave
Major Charles F. Chunn
Captain William F. Rose

BRONZE STAR MEDAL

Captain Albert G. Abriel
Captain Trogler F. Adkins
Captain Thomas F. Ahearn
1st Lt. Anna B. Berret
Major Howard C. Bos
Major Lyman Brewer
Captain Clarence R. Brott
Major Frederick W. Bowers
Captain Freeman F. Brown
Captain Walter L. Byers
1st Lt. Mary A. Campbell
Major Edwin L. Cantlon
1st Lt. Florence M. Carlisle
Major Samuel B. Childs
Major Henry B. Clark, Jr.
1st Lt. Dessie M. Cox
1st Lt. Opal G. Davis
Major Paul L. Dent
1st Lt. Grova-Nelle Dickson
Major George E. Donaghy
1st Lt. Rhoda E. Donahoe
Captain Ernest A. Doud
1st Lt. Katherine Driscoll
Captain James C. Drye
1st Lt. Catherine V. Elliott
1st Lt. Christina M. Eschenberg
1st Lt. Dorothy E. Fischer
Captain Clyde E. Flood
Major Norris H. Frank
Captain Wooster P. Giddings
1st Lt. Ethel M. Gregg
Captain Glen H. Gummess
Captain Julius A. Gurvey
Major Frank Hall
Captain Robert H. Haralson, Jr.
1st Lt. Laura R. Hindman
1st Lt. Esther A. Hinshaw
Captain Werner F. A. Hoeflich
Major Henry L. Hoffman
Captain Frank C. Hofrichter
Major George S. Hopkins
Major Lawrence E. Hurt
Major Fred J. Jarvis
Captain Irwin Kaplan
Captain Wolfgang W. Klemperer
1st Lt. Mary E. Lombardo
1st Lt. Irene E. Legako
Captain William M. Lees
1st Lt. Odessa M. Lindsey
Major Forrest E. Lowry
Captain Hugh A. MacMillan, Jr.
Major Gordon F. Madding
Major James M. Mason III
1st Lt. Mary A. Matlock
Captain John R. McDaniel
Major Leon M. Michels
1st Lt. Frances A. Miernicke
Captain Herbert L. Moore

BRONZE STAR MEDAL (CONT'D)

Captain William A. Nelson, Jr.
1st Lt. Elsie M. Nichols
Captain Seymour L. Oscher
1st Lt. Lena O. Pizzolatto
Captain Ida G. Price
1st Lt. Mary W. Randolph
1st Lt. Julianne M. Rheaume
1st Lt. Helen B. Rickert
Major Robert W. Robertson
1st Lt. Josefina M. Rodriguez
Major Edward E. Rose
Captain Charles A. Schiff
Captain Benjamin I. Schneiderman
Major Lawrence M. Shefts
Major Howard B. Shorbe
Captain Gerald Shortz
Major Werner G. Sittler
1st Lt. Anna M. Smith
1st Lt. Code A. Smith
Captain Robert Sneiderman
1st Lt. Lina J. Stratton
1st Lt. Ruth C. Sobeck
Captain Charles M. Swindler
Major Floyd D. Taylor
Major Milton Tinsley
1st Lt. Mary A. Usnik
Captain Maurice J. Walsh
Captain John D. Welch
Captain Charles W. Westerfield
Captain Donald B. Williams
Major Robert H. Wylie
Captain Dominick A. Zurlo
Tec 4 Waynewright A. Ballard
Tec 4 Edgar W. Bartlett
Tec 4 John H. Broda
Tec 5 Sidney C. Edmunds
Tec 4 William O. Edwards
Tec 4 Thomas L. Dixon
Tec 4 Julian Egnaczewski, Jr.
Tec 5 George B. Fisher
Tec 4 Lester M. Goodwin
Tec 4 Rolland C. Hinrichs
Tec 4 Pius Hornstein
Tec 5 Ben Lefkowitz
Tec 4 Benjamin L. Lingerfelt
Tec 5 Ted B. Lotz
Tec 4 John P. Martin
Tec 5 Zafiris J. Karathanasis
Tec 4 Peter R. McCarthy
Tec 4 Vern E. McLaughlin
Tec 4 Alfred A. Odermann
Tec 5 Salvatore L. Palumbo
Tec 4 Raymond J. Payne
Tec 4 Paul Randolph
Tec 5 Quindo G. Romano
Tec 4 Edward E. Schneeweiss
Tec 4 Donald R. Scott
Tec 3 Franklin D. Seale
Tec 4 Paul A. Slavik
Tec 4 Guy E. Teal, Jr.
Tec 4 Adalbert J. Trautner
Tec 4 Charles J. Voss
Tec 4 Eugene Weaver
Tec 5 Keith V. Welborn
Tec 4 Guy E. Teal, Jr.
Tec 4 Ernest L. Tignanelli

PURPLE HEART MEDAL

Major John E. Adams
Captain Trogler F. Adkins
Major Howard C. Bos
Major Berget H. Blocksom
Captain Clarence R. Brott
Major George A. Calaway
Major Charles F. Chunn
1st Lt. Dessie M. Cox
Captain Anthony J. Emmi
2nd Lt. LaVerne Farquhar
Captain Joseph Finegold
Captain Ben Z. Firestein
Major Ellery C. Gay
Captain Glen H. Gummess
Captain Julius A. Gurvey
Captain William M. Hart
1st Lt. Laura R. Hindman
Major George S. Hopkins
Captain John L. Maple
1st Lt. Elsie M. Nichols
Major Edward B. Robinson, Jr.
Major Howard B. Shorbe
1st Lt. Ruth C. Sobeck
Captain Charles M. Swindler

PURPLE HEART MEDAL (CONT'D)

Captain James J. Thomas
Major Milton Tinsley
Major Robert F. Sullivan
Tec 5 Mathias J. Bieber
Tec 5 Robert L. Burghardt
Tec 4 Clayton F. Cady
Tec 5 Sidney C. Edmunds
Tec 4 William O. Edwards
Tec 5 Frederick F. Frankenberg
Tec 5 Zafiris J. Karthanasis
Tec 5 Theron G. McCombs
Tec 4 William H. Ryan
Tec 4 John Semivan
Pvt. Stanley Spurgiasz

HONORARY ORDER OF BRITISH EMPIRE MEDAL

Major Robert W. Robertson

MEDALHA DE GUERRA (BRAZILIAN MEDAL)

Captain Arkie B. Bowyer

COMMENDATION FROM FIFTH ARMY COMMANDER

Major Frederick W. Bowers
Major Gene D. Caldwell
1st Lt. Esther R. Collins
1st Lt. Dessie M. Cox
1st Lt. Opal G. Davis
Major Norris H. Frank
Major Ellery C. Gay
Captain Glen H. Gummess
Captain William M. Lees
1st Lt. Irene C. Legako
Captain Frank C. Massengill
1st Lt. Ruth Ponko
Major Edward B. Robinson, Jr.
1st Lt. Betty F. Verazin
Tec 4 James W. Ashburn
Pvt. Edgar E. Barnett
Tec 4 Edgar W. Bartlett
Tec 5 Louis D. Capalbo
S/Sgt. Philip Cusumano
1st Sgt. Frederick A. Dreiss
Tec 4 Bernard Gaughran
Tec 5 Sidney C. Edmunds
Tec 4 Benjamin Honigman
S/Sgt. William P. Koch
Tec 4 Frank M. Looney
Tec 4 Paul A. Nemmert
Tec 4 Raymond J. Payne
Tec 4 Edward E. Schneeweiss
Tec 4 John Semivan
Tec 4 Guy E. Teal, Jr.

VI - PUBLICATIONS AND REPORTS

PUBLICATIONS

ORIGINAL ARTICLES BY MEMBERS OF THE 2ND AUXILIARY SURGICAL GROUP

SHOCK AND GENERAL SUBJECTS

"PORTABLE HAND-DRIVEN SUCTION MACHINES"
Lyman A. Brewer III, Major, MC-AUS
Bulletin U.S. Army Medical Department, No. 75, April, 1944.

"SHOCK AND HEMORRHAGE"
James M. Sullivan, Major, MC-AUS
Medical Bulletin, NATOUSA, Vol. 1, No. 6, June, 1944.

"GASTRIC DILATION IN WAR INJURIES"
Robert D. Beech, Captain, MC -AUS
Luther H. Wolff, Major, MC-AUS
Medical Bulletin, MTOUSA, Vol. 3, No. 6, June, 1945.

"RESUSCITATION OF SEVERELY WOUNDED CASUALTIES"
Joseph J. Lalich, Captain, MC-AUS
James M. Mason III, Major, MC-AUS
Surgery (In press).

"CARE OF THE NON-TRANSPORTABLE CASUALTY"
Gordon F. Madding, Major, MC-AUS
Paul A. Kennedy, Captain, MC-AUS
William A. Weiss, Captain, MC-AUS
Surgery, Gynecology and Obstetrics (in press).

"SHOCK IN FORWARD AREAS"
James M. Sullivan, Major, MC-AUS
Wisconsin Medical Journal (in press).

ANESTHESIA

"ANESTHESIA IN THE COMBAT ZONE"
Gerald Shortz, Captain, MC-AUS
Bulletin U.S. Army Medical Department, No. 79, August, 1944.

"THE MANAGEMENT OF THE FIRST PRIORITY SURGICAL CASUALTY FROM THE ANESTHETIC VIEWPOINT"
Gerald Shortz, Captain, MC-AUS
Journal Indiana State Medical Association, Vol. 38, February, 1945.

"ENDOTRACHEAL ANESTHESIA IN THE COMBAT ZONE"
Frederick W. Bowers, Major, MC-AUS
Journal of Anesthesiology (in press).

"THE USE OF CURARE FOR ABDOMINAL SURGERY IN SERIOUSLY WOUNDED BATTLE CASUALTIES"
Ernest A. Doud, Captain, MC-AUS
Gerald Shortz, Captain, MC-AUS
Journal of Anesthesiology (submitted for publication).

GENERAL SURGERY

"FORWARD SURGERY VIEWED FROM THE BASE"
Wooster P. Giddings, Captain, MC-AUS
Medical Bulletin, NATOUSA, Vol. 2, No. 4, October, 1944.

"TOURNIQUET PROBLEMS IN WAR INJURIES"
Luther H. Wolff, Major, MC-AUS
Trogler F. Adkins, Captain, MC-AUS
Medical Bulletin, MTOUSA, Vol. 3, No. 6, June, 1945.
Bulletin U.S. Army Medical Department, No. 87, April, 1945.

"BATTLE INJURIES OF THE COLON AND RECTUM"
Lawrence E. Hurt, Major, MC-AUS
Medical Bulletin, MTOUSA, Vol. 3, February, 1945 (abstract)
Bulletin U.S. Army Medical Department (in press).

"EXPERIENCE WITH LUMBAR SYMPATHETIC GANGLIONECTOMY FOR WOUNDS OF MAJOR BLOOD VESSELS OF THE LOWER EXTREMITY"
James M. Mason III, Major, MC-AUS
Wooster P. Giddings, Captain, MC-AUS
Surgery, Gynecology and Obstetrics, Vol. 81, August, 1945.

"THE SURGICAL MANAGEMENT OF COLON AND RECTAL INJURIES IN THE FORWARD AREAS"
Lawrence E. Hurt, Major, MC-AUS
Annals of Surgery (in press).

"PREOPERATIVE DIAGNOSIS OF THE RECENTLY WOUNDED ABDOMEN"
Leon M. Michels, Major, MC-AUS
Journal, American Medical Association (in press).

" A STUDY OF CASE RECORDS OF 95 INSTANCES OF WOUNDS OF THE UROGENITAL SYSTEM"
Walter L. Byers, Captain, MC-AUS
Surgery, Gynecology and Obstetrics (in press).

"EXPERIENCE IN THE MANAGEMENT OF THE ABDOMINAL WOUNDS OF WARFARE"
Fred J. Jarvis, Major, MC-AUS
Edward V. Platt, Captain, MC-AUS
Surgery, Gynecology and Obstetrics (submitted for publication).

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